Characteristics of Ozone Episodes during SCCCAMP 1985

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ABSTRACT

Extensive meteorological and air chemistry measurements were obtained along the Ventura and Santa Barbara county coastal areas in California during four 2–3 day case studies conducted during the September–October 1985 South-Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP 1985). An overview of the characteristics of ozone episodes during these four case studies is given, showing that the episodes are associated with warm, high pressure systems with light winds. In the absence of easterly winds, the observed ozone in the region is primarily due to local sources. At other times, easterly wind components transport ozone and its precursors from large source regions to the east (i.e., Los Angeles County). This transport sometimes occurs in inland valleys at elevations up to 600 m, and sometimes occurs over the ocean near the surface. Local sea breezes, mesoscale eddies, and terrain-generated winds often cause complex flow patterns and recirculation of pollutants.

1. Introduction

The objective of the South-Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP 1985) was to provide an extensive database to be used for analyzing the causes of ozone formation in the region. The SCCCAMP region consists of the counties of Ventura and Santa Barbara and is located immediately to the west of Los Angeles County. Figure 1 contains a map of the region, showing the topography and the major geographic features. The entire region, with the exception of the northern parts of Santa Barbara and Ventura counties, exhibits numerous days with exceedances of the 1-h regulatory standard (120 ppb) per year. The air pollution potential in the region is high due to high temperatures, clear skies, limited vertical mixing, light and variable winds, and blocking by mountains. There are many significant local air pollution sources in the region, although the sources in adjacent Los Angeles County are much larger. Geogenic oil and gas that seep into the area emit methane and other gases into the atmosphere. In addition, there are 25 oil and gas platforms in the channel area with about five more platforms planned in the next decade. In fact, the overall SCCCAMP study is driven by the need to answer the question whether the planned oil and gas platforms will adversely affect local air quality.

Previous data collection efforts in the region were lacking one or more important components. It was decided to conduct a major five-week field study (SCCCAMP) in September and October 1985, to provide a comprehensive database for the development and evaluation of photochemical simulation models (Dabberdt and Viezee 1987). There were two types of measurements: 1) routine measurements taken throughout the five-week period, and 2) intensive measurements taken only during the four 2–3 day intensive case study periods, which were selected on the basis of daily forecasts of weather and air pollution potential. Routine data are listed in the following:

- standard National Weather Service (NWS) observations.
- A mesoscale network of wind observations.
- Mixing-depth observations by 11 Doppler Acoustic Wind Sounders (DAWS).
- Surface air chemistry at many sites.

Intensive case study data included the previous list, plus the special data listed in the following:

- wind data over the channel from a dual-Doppler radar system.
- Mixing depth observations by four aircraft.
- Aerometric observations by three aircraft.
- Tracer gas releases and tracking by means of aircraft and a network of surface monitors.

All data have been placed in a consistent data archive that is made available through the National Technical Information Service (NTIS).

Detailed descriptions of the data collection efforts during the intensive case study periods are given by Dabberdt and Viezee (1987) and Viezee et al. (1987),

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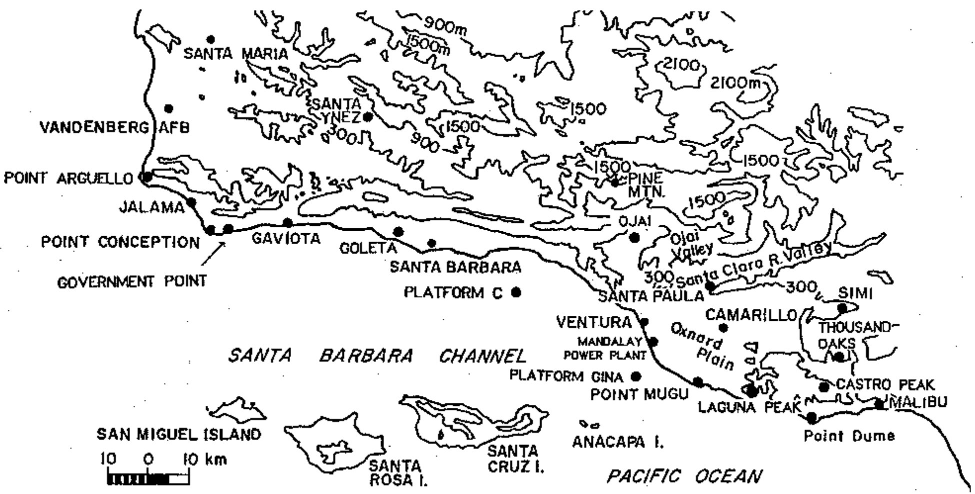


FIG. 1. Topographic map of SCCCAMP region, with a few major towns and cities and geographic features shown (from Dabberdt and Viezee 1987). Los Angeles County is adjacent to the eastern part of this map. Contour elevations are given in meters.

and a summary is given by Hanna et al. (1991) in the first paper in this special issue. Additional discussions of the data and the results of various data analysis projects can be found in other papers in this issue. For example, the results of the tracer experiments are described by Strimaitis et al. (1991).

This paper presents an overview of analyses of the data from the four intensive case study periods. First, graphs and tables of meteorological and air chemistry observations are presented for the entire five-week period, illustrating typical variations in these parameters with time and geographic location. Similarities and differences among the four intensive case study periods are illustrated. Then the intensive case studies are discussed individually, covering the various components of the study, including the characteristics of transport, dispersion, and air pollution concentrations and fluxes during the period. Emphasis is on identifying meteorological conditions associated with high ozone concentrations.

2. Overview of characteristics of five-week SCCCAMP 1985 experiment

Before describing the four individual case studies, it is instructive to present some graphs illustrating the variation of observed parameters during the entire five-week period. Figure 2 illustrates the day to day variation of mixing depth, wind direction, and 850-mb temperature in the region, and Figure 3 illustrates the concurrent variation of ozone concentrations at several stations (Dabberdt and Viezee 1987). It is seen in Fig. 2 that relatively cool air with high mixing depths and westerly flow occurred during most of the period, especially during the first two weeks of the experiment. However, during the four case study periods the air warmed by 5°–10°C, the mixing depth dropped to 300 m or less, and the flow at elevations of a few hundred meters turned to the east. The time series in Fig. 3 of the daily maximum hourly ozone concentrations at the surface at coastal and inland sites show a general increase in ozone concentrations by a factor of two or more during the case study periods. Figure 4 continues this analysis by presenting time series of daily ozone maximum for three different pairings of stations, showing differences in ozone concentrations with respect to west to east position on the coast (top), to offshore and inland position (middle), and to sea-level or mountaintop elevation (bottom). The monitor station locations are given in Fig. 1. It is seen that case study period 4 (2–4 October) was different from the other three periods in the sense that the air mass containing ozone pollution was located at low levels over the water in period 4. In contrast, during the other periods, the ozone concentrations tended to be higher inland than offshore, and higher on the mountaintops than at sea level. It is interesting that the peak concentrations along the coastline during each case study period show little variation from west to east, although the time duration of high concentrations is shorter in the western portion of the region, probably due to its greater distance from the pollution source region.

It is useful to attempt to determine causalities during the SCCCAMP 1985 period. For example, even though

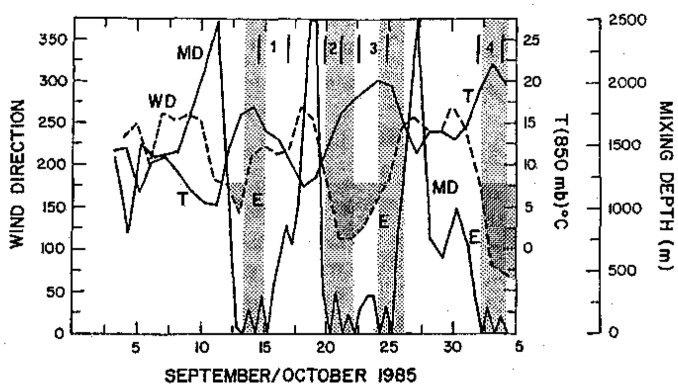


FIG. 2. Daily variation of mixing depth (MD) and 850-mb temperature (T) at Vandenberg (western portion of region) and morning wind direction (WD) at Laguna Peak (450 m MSL in the eastern portion of the region); shading indicates periods with easterly wind component. The intensive case study periods are indicated by numbers 1, 2, 3, and 4. Figure taken from Dabberdt and Viezee (1987).

high ozone concentrations are known to be well correlated with high 850-mb temperature, it is not the high 850-mb temperature alone that is causing the development of high ozone concentrations. Rather, the high 850-mb temperature is often an indicator of subsiding air in a high pressure system, which is usually associated with low mixing depths and clear skies and sometimes associated with warm air advection. In addition, high ozone concentrations in Santa Barbara County have been found to be correlated with pressure gradients that would suggest a wind from the southeast.

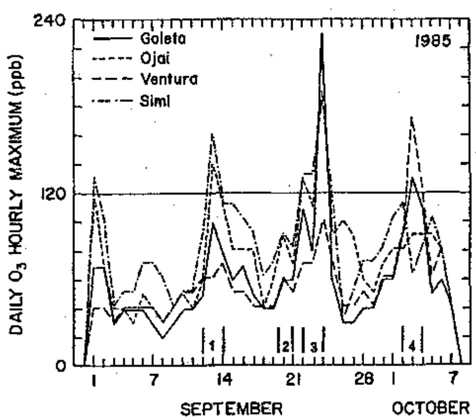


FIG. 3. Daily variation of maximum hourly surface concentration. Goleta is on the coast just west of Santa Barbara. Ventura is on the coast in the middle of the region, Ojai is in an inland valley about 15 km from Ventura, and Simi is in another inland valley about 25 km from the coast in the eastern part of the region. The intensive case study periods are indicated by the numbers 1, 2, 3, and 4. Figure taken from Dabberdt and Viezee (1987).

Analyses of the ozone concentration time series at Goleta (representative of coastal sites in the region) and the general synoptic conditions in the region during the five-week SCCCAMP 1985 period show that the ozone episodes during the SCCCAMP period occur during synoptic situations characterized by tropical cyclones approaching from the southeast, preceded by clear skies with high pressure, and usually followed by cloudy conditions. According to Cross (1988), there are typically four tropical cyclones, on the average, in the eastern North Pacific during the month of September, and their influence is often felt in southern California. The synoptic pattern of cold fronts advancing from the west, followed by clear skies, calm winds, high pressure, and occasionally punctuated by tropical cyclones advancing from the southeast is typical of September conditions on the east coast of continents in "horse latitudes" between the extratropical westerlies to the north and tropical easterlies to the south.

In a typical "idealized" 2–3 day ozone episode during SCCCAMP 1985, the first day is marked by high pressure with clear skies, light winds, low mixing depth, and high 850-mb temperature, allowing the build up of ozone in the area around local sources. The second day is marked by similar meteorological conditions, except that easterly winds begin to increase in the region marked by warm air advection on the northern fringes of an approaching tropical storm. On the third day, easterly winds spread over much of the region causing transport of polluted air masses. The episode ends when cloudiness removes the possibility of ozone formation and associated vertical mixing causes dilution of the polluted air.

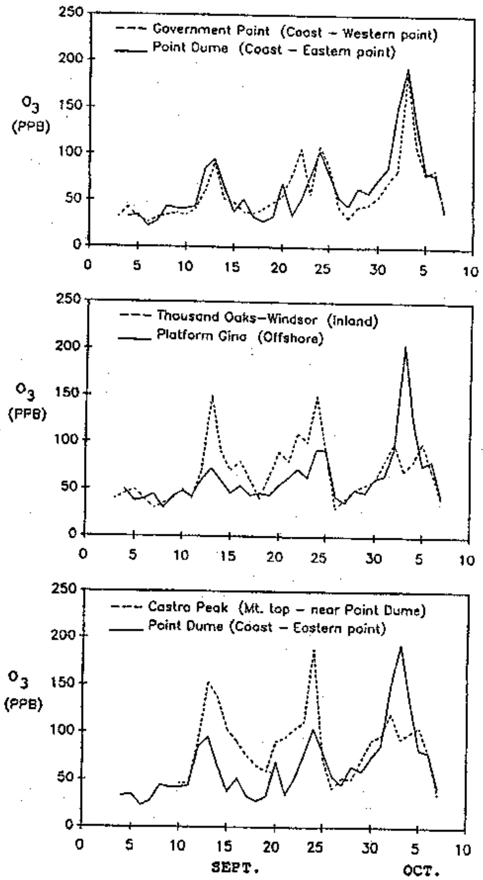


FIG. 4. Daily variation of maximum hourly surface ozone concentration, for three different pairings of stations. (Top—stations at western and eastern ends of coast; middle—stations inland and offshore; bottom—stations on mountaintop and at sea level.)

In order to illustrate the variation of mixing depth and vertical stability during the five-week period, a time series of afternoon temperature profiles observed by the Point Mugu (coastal) radiosonde is given in Fig. 5. Continuity in the mixing depth and its rate of change can be seen from day to day, and the figure verifies that the case study periods, with high ozone concentrations, are related to time periods with low mixing depths and stability in the lower atmosphere. If there were room on the figure to plot wet-bulb temperature profiles, the subsidence inversion development prior to the case study periods would be more obvious. Generally the wet-bulb temperature decreases rapidly with height in the subsidence inversion above the mixing depth.

The vertical temperature structure of the marine air is a factor in determining whether a polluted air mass flowing towards the region from the Los Angeles basin would pass mostly out to sea or would infiltrate through the inland Simi and Santa Clara valleys. During the first three case studies, the polluted air mass from Los Angeles extended to several hundred meters in height and tended to spill into the SCCCAMP region through inland valleys as well as along the coastal areas. But during case study period 4, the relatively shallow pol-

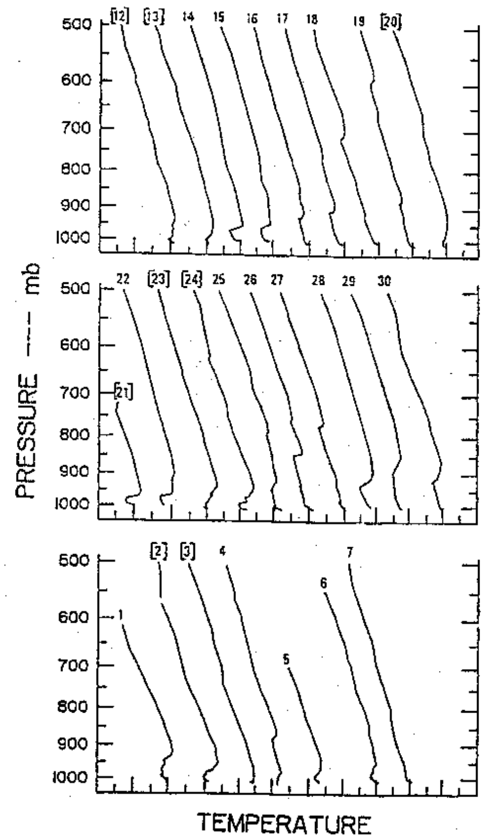


FIG. 5. Radiosonde temperature soundings in midafternoon from Point Mugu (except Vandenberg on 14–15 September, 21–22 September, 28–29 September, and Loyola on 5 October). The Loyola station is located near the coast just off the eastern edge of the map in Fig. 1. The temperature scale is 20°C between the tall hatches on the horizontal axis. Dates are indicated at the top of each sounding, and case study dates are bracketed.

luted air mass appears to have been blocked by the mountains and was forced to follow a coastal or over-water trajectory. The relatively intense stability during the last case study is not evident in the Point Mugu soundings in Fig. 5, but can be better seen looking at the average mixing depth over the region as measured by many types of sounding devices (Baxter 1991; McElroy and Smith 1991).

3. Characteristics of case study 1, 11–13 September 1985

The period between 11 and 13 September 1985, includes the only ozone episode that occurred during the first three weeks of the SCCCAMP experiment, except for 11–13 September this period was generally characterized by an upper-level trough over the region and relatively frequent cloudiness and above-normal vertical mixing. However, on 11 and 12 September high pressure moved into the region with accompanying subsiding air, clear skies, and light to moderate winds. The Point Mugu soundings in Fig. 5 show the shallow mixing depth and the subsidence inversion. The build up of photochemical pollutants on 11 September and part of 12 September appears to be caused mostly by local sources.

Starting on 12 September, easterly winds aloft gradually spread into the region due to a tropical cyclone approaching from the southeast, resulting in some advection of pollutants into the SCCCAMP region from the Los Angeles basin. However, westerly winds persisting in the western part of the region did not allow the advected air mass to pass very far beyond Ventura County. This situation continued through 13 September and the early part of 14 September, after the weak cold front passing through the region from the northwest broke up the episode through its strong vertical mixing and westerly winds. The synoptic situation that has just been discussed is pictured by the surface map and satellite photograph shown in Fig. 6. The cold front in northern California and the tropical storm near the southern edge of the figure are seen to be associated with extensive cloud shields.

The wind field patterns produced by a diagnostic wind analysis, based on interpolation of observed winds, are shown in Fig. 7 for local times of 0600 and 1200 PDT on 13 September (Kessler et al. 1989). An elevation of 300 m AGL is chosen for presentation because aircraft observations verify that this episode was characterized by high ozone concentrations and advection at that level. Surface wind field patterns were also produced by the diagnostic analysis, but showed much more variability than the 300-m patterns due to the influence of local terrain. These 300-m wind fields have the following characteristics:

- northerly wind components are observed over the western part in the region in the ocean off Points Arguello and Conception throughout the period,
- southwesterly flow (i.e., a sea breeze) is observed along the coast east of Santa Barbara at midday (1200 PDT), and
- easterly flow is observed along the coast and inland east of Point Conception at late night (0600 PDT).

The daily ozone concentration time series for the stations in Figs. 3 and 4 show that concentrations began increasing on 12 September, and that the 120 ppb standard was exceeded at some inland and mountain-top stations on 13 September. This band of high concentrations did not extend to the western part of the region, however (e.g., the Goleta data in Fig. 3). Concentrations were not quite as high on 14 September and then returned to lower values on 15 September following the cold front passage. Aircraft observations indicated ozone concentrations in the early afternoon on 13 September over Ventura County exceeding 200 ppb around 300–400 m above the surface, although surface concentrations were much lower (about 60 ppb). The evidence suggests that this material may have been advected into the study region along the coast from the southeast. As the mixing layer grew over land during the morning, some of the pollutants in the elevated layer were mixed to the surface. The highest concentrations in the midafternoon (1500 LST) occurred on elevated coastal terrain, although lower elevation locations in Ventura County such as Simi Valley observed ozone concentrations in excess of 160 ppb. As discussed by Killus and Moore (1991), the hydrocarbon sampling during the afternoon indicated the presence of both aged urban air and geogenic/fugitive air masses over Ventura County (geogenic/fugitive refers to naturally occurring HC seep emissions and fugitive HC emissions from oil and gas processing facilities). Halocarbon concentrations of compounds such as F_{11} (a surrogate of Los Angeles pollution) were elevated, suggesting that some of the pollution had been advected from that region. There were no exceedances of ozone air quality standards (120 ppb) in Santa Barbara County throughout the whole episode. During the afternoon, aircraft observations indicated only moderate ozone concentrations aloft over Santa Barbara with no evidence of concentrations greater than 120 ppb. During the evening the aircraft data indicate that the ozone-laden air mass at an elevation of a few hundred meters over Ventura County drifted out over Santa Barbara and the channel, but it was so late in the day that there was insufficient vertical mixing to bring it down to the surface.

The results from the tracer experiment that was conducted during the first case study period are consistent with the general features of the wind field and ozone observations (Strimaitis et al. 1991). For example, releases of two types of tracer gas were made from platform Hondo, in the western part of the Santa Barbara Channel, in the early morning on 13 September. The tracer clouds were observed to move onshore with the

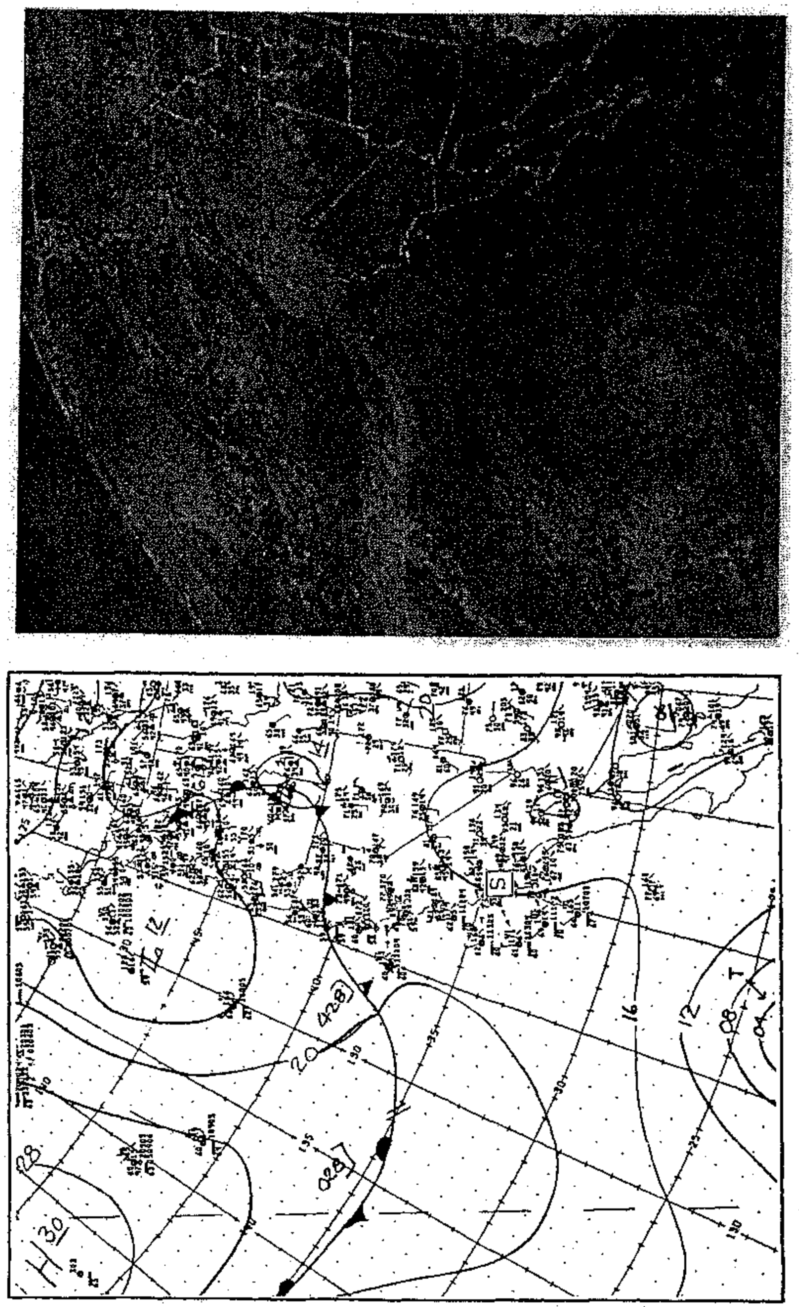
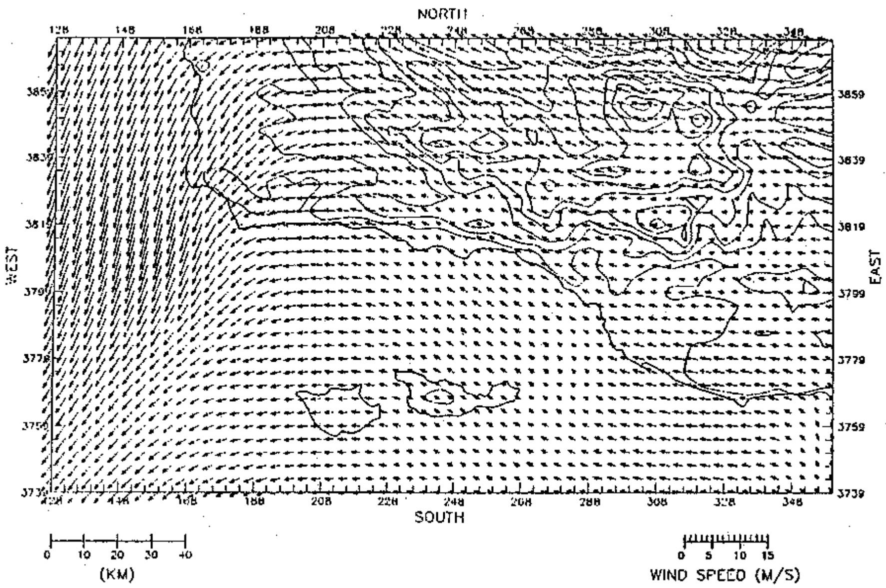


FIG. 6. Surface weather map (1700 PDT) and satellite photograph (1501 PDT, 4 km, visible) for 13 September 1985 (from Viezee et al. 1987). The SCCCAMP region is marked by an "S" and the position of the tropical storm is marked by a "T" on both maps.



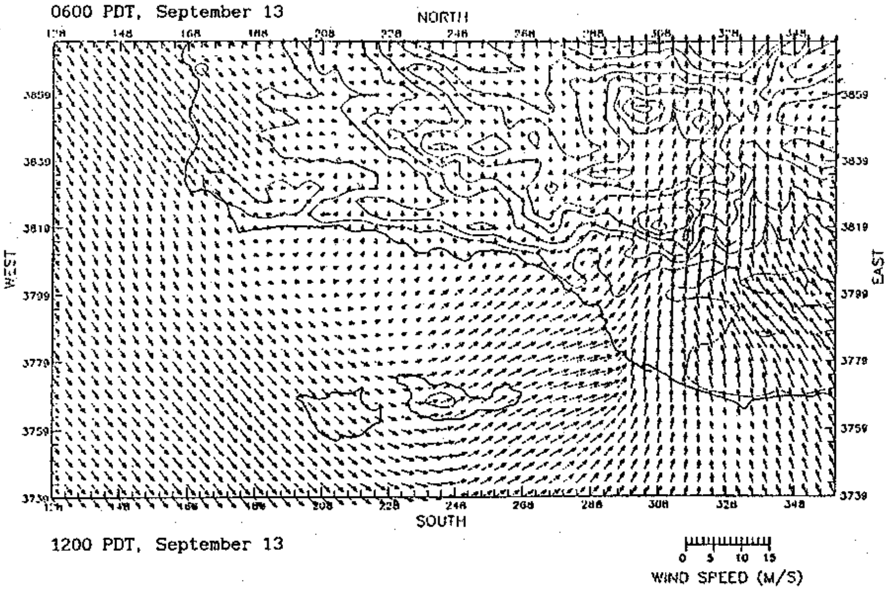


FIG. 7. Interpolated observed wind fields at an elevation of 300 m for 0600 (a) and 1200 PDT (b) on 13 September for the first case study period (from Kessler et al. 1989).

sea breeze during the day and then moved offshore with the land breeze in the evening. Another tracer release took place from R/V *Acania* off Government Point in the western part of the region, but this tracer was caught in the northwesterly flow over the ocean and was advected to the south and east of the SCCCAMP region.

4. Characteristics of case study 2, 20–21 September

Case study 2, including 20 and 21 September, was associated with a transition between the upper-level trough that covered the SCCCAMP region during the first part of September and the upper-level ridge that formed for the remainder of the five-week study. A surface high with associated low mixing depth and strong subsidence inversion (see the vertical temperature profiles in Fig. 5) was centered over the region. No major easterly flow patterns developed during this case study period. The synoptic situation during case study 2 is pictured in Fig. 8, showing the usual persistent northerly flow component at the surface over the ocean and the light winds at the coastal stations. Hurricane Terry is visible on the satellite photograph as a spiral of clouds at a location off the tip of Baja California. The storm is not yet near enough to influence the winds in the boundary layer in the SCCCAMP region, and the 300-m wind velocities on the interpolated observed wind field displayed in Fig. 9 show the influence of the sea- and land-breeze cycle along the Santa Barbara and Ventura coastal region. Channeling of the flow by the coastal mountains can be seen in most regions.

Moore et al. (1991) state that on 21 September, the nitrous oxide (NO) and nitrous dioxide (NO_2) concentrations in the early morning were typical of those from isolated and local influences (e.g., isolated morning NO maximum at Santa Barbara and Simi Valley). The morning peak NO_2 concentration at Simi Valley was only 40 ppb. Areawide carbon monoxide (CO) concentrations were not significantly elevated on either day of the episode, suggesting a lack of transport from Los Angeles. The peak concentrations occurred primarily at sites in Santa Barbara located near main roads, due to emissions from local traffic.

Because this period was marked by a typical diurnal sea- and land-breeze cycle and the general offshore flow was out of the northwest, this case study period was the mildest of the four case study periods in terms of peak ozone concentrations. For example, ozone concentrations in Santa Barbara did not exceed 70 ppb during the whole episode. The maximum ozone concentrations occurred over a broad region of the inland portion of Ventura County, but were limited on both days to 60–100 ppb, which is below the air quality standard of 120 ppb. Aircraft spirals made during 20 and 21 September revealed only slightly elevated (40–70 ppb) ozone concentrations aloft. During the morning of 21 September there was actually a significant ozone depletion over the first 800 m above the surface due to chemical reactions with NO_x. The ozone concentration time series at individual monitoring stations during case study period 2 were similar to those during case study period 1, as seen in Fig. 4. Offshore concentrations were about 60%–70% of inland concentrations, and low-level concentrations were about 50% of those on mountaintops.

The fixed and aircraft hydrocarbon observations showed relatively clean air offshore [maximum nonmethane hydrocarbon (NMHC) < 100 ppb] on both days (Killus and Moore 1991). Other sampling sites showed an influence of local emissions of hydrocarbons, with no evidence of large contributions of hydrocarbons from distant source regions.

The tracer cloud movements for early morning releases on 20 September from an offshore platform in the western portion of the region and from the Mandalay power plant site (along the eastern coast) agree with the observed wind fields (Strimaitis et al. 1991). The tracer release from the platform moved offshore briefly in the early morning when it was still influenced by the land breeze, then came onshore with a southwesterly sea breeze during the later morning and afternoon. During the night, it was transported back out to sea by the land breeze. The release from the Mandalay power plant followed the same pattern, but was advected out of the region to the east by the next day.

It can be concluded that case study period 2 produced the least serious air pollution concentrations of the four case studies, with most of the ozone observed in the SCCCAMP region generated by local sources. The region was dominated by moderate high pressure with a subsidence inversion and typical sea- and land-breeze patterns.

5. Characteristics of case study 3, 23–25 September

A significant ozone episode occurred in the region during case study 3 on 23–25 September as shown by the ozone concentration time series in Figs. 3 and 4. High pressure with subsidence and a typical sea-breeze cycle was followed by light easterly flow on the northern reaches of Tropical Depression Terry. Consequently, the polluted air mass that occupied the mixed layer in the eastern part of the region (i.e., the Los Angeles basin) was advected over the western part of the region by the second day of the episode. It also should be mentioned that case studies 2 and 3 are both part of a several-day ozone episode, and that ozone was continually building up in the region from 20 through 24 September. Figure 10 displays the surface weather map and the satellite photograph for 24 September. There were many clouds around the storm, which was centered about 400 km to the south-southwest of the SCCCAMP region, but the SCCCAMP region itself remained in clear air. The Los Angeles surface temper-

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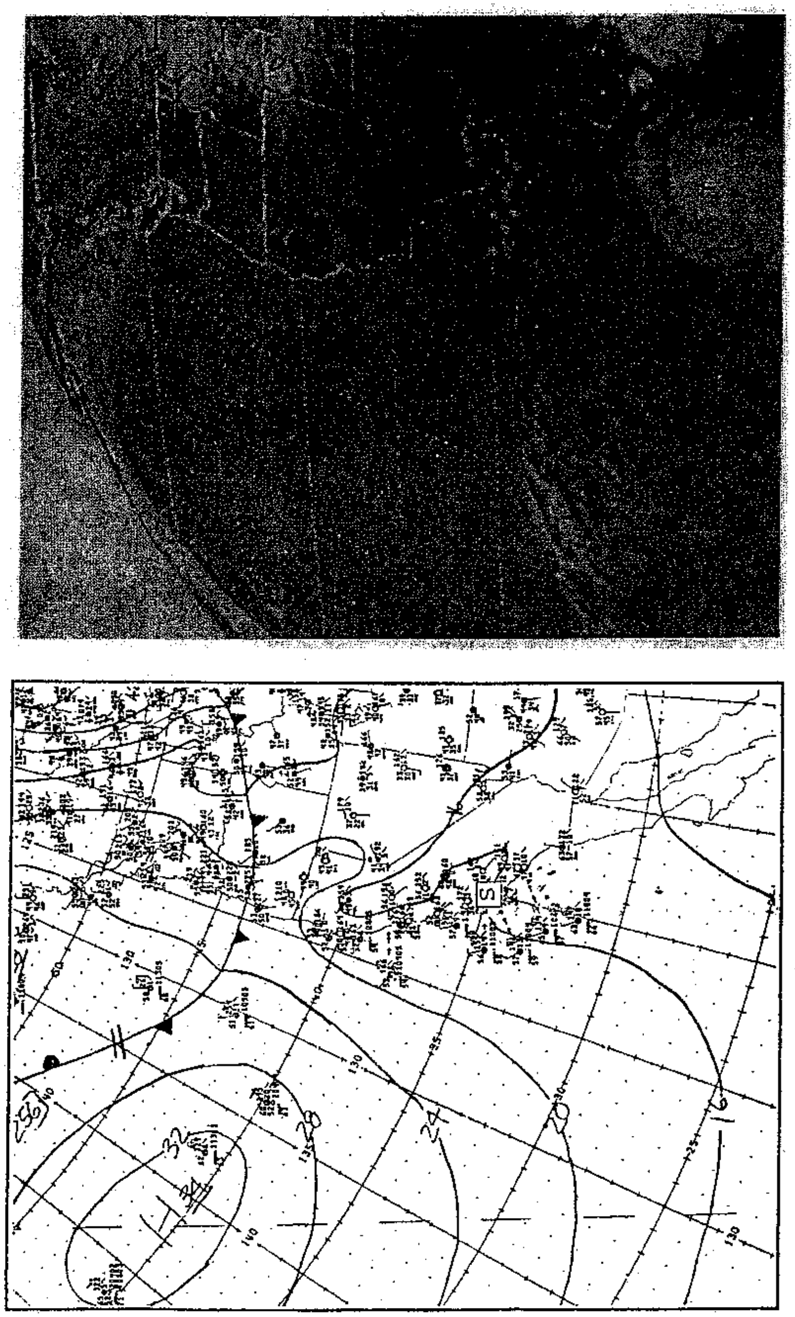

FIG. 8. Surface analysis (0500 PDT) and satellite photograph (1401 PDT, 4 km IR) on 21 September 1985 (from Viezee et al. 1987). The SCCCAMP region is marked by an "S" and the position of the tropical storm is marked by a "T" on the satellite photograph.

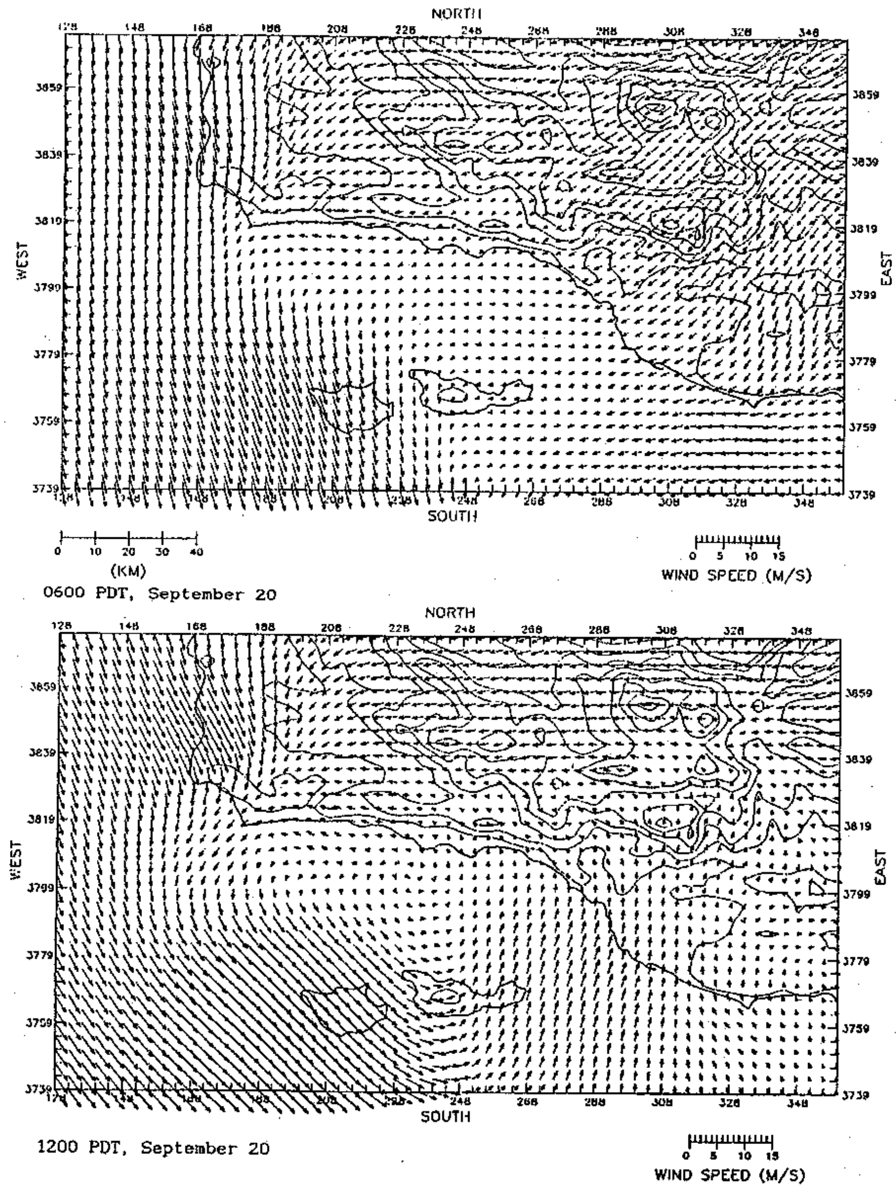

FIG. 9. Interpolated observed wind fields at an elevation of 300 m for 0600 (a) and 1200 PDT (b) on 20 September for the second case study period (from Kessler et al. 1989).

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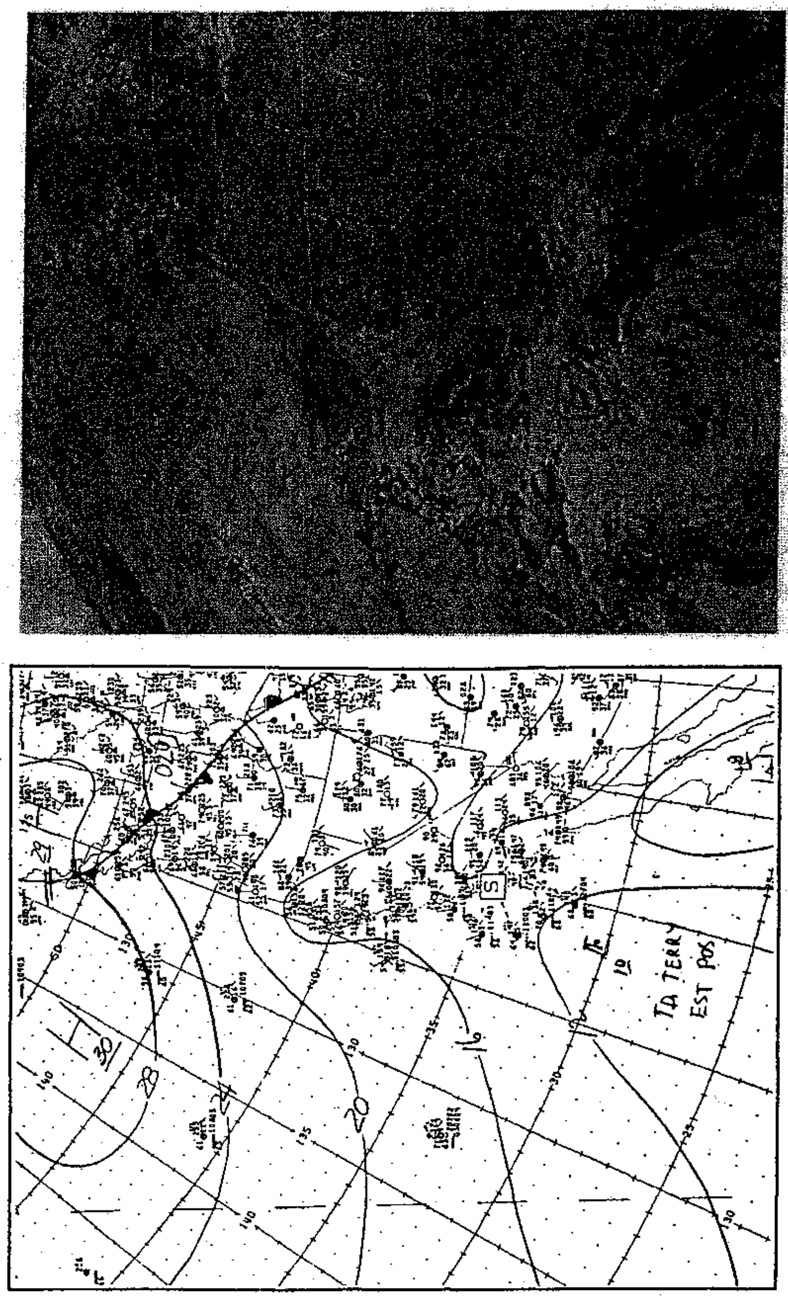

FIG. 10. Surface weather map (1700 PDT) and satellite photograph (1101 PDT, 2 km, visible) for 24 September 1985, during case study 3 (from Viezee et al. 1987). The SCCCAMP region is marked by an "S."

ature and 850-mb temperature on this day were the highest recorded during the month. The combination of low mixing depths, high temperatures, clear skies, and light easterly winds was ideal for ozone formation throughout the SCCCAMP region.

The interpolated observed wind field at the 300-m elevation is shown in Fig. 11 for 0600 and 1200 PDT on 24 September. On the previous day, the usual north-to-northwest flow persisted in the western part of the domain, with light southerly or easterly flow in the eastern part. The sea- and land-breeze cycle was more evident on the 23d. As shown in Fig. 11, by 1200 PDT on the 24th moderate easterly winds covered nearly all of the domain. The episode ended abruptly on 25 September as air marked by cloudy skies with increased vertical mixing entered the region. The time series of radiosonde soundings in Fig. 5 also illustrate the change in vertical mixing potential, showing a strong subsidence inversion on 23 and 24 September, and a deepening well-mixed layer on 25 through 27 September.

Ozone concentrations at the surface in Ventura County on the 23d were about 60 ppb at 0800 PDT in the morning (Moore et al. 1991). At the same time, the local NO maxima at Santa Barbara and Simi Valley were already twice the concentrations observed during 20 and 21 September (Simi Valley > 150 ppb). By 1300 PDT a broad range of ozone concentrations in excess of the air quality standard (120 ppb) was observed throughout Ventura and Santa Barbara counties. The band of maximum concentrations extended westward from Simi Valley, where the areawide peak concentration was observed. Peak ozone concentrations occurred during the next two hours. In some inland and elevated areas the high ozone concentrations persisted until after 1700 PDT.

Nonmethane hydrocarbon (NMHC) concentrations offshore during 23 September were about 250 ppb or larger during the morning, but dropped to clean air levels during the afternoon as a result of both chemical breakdown and the sea breeze (Killus and Moore 1991). In interior regions of Ventura County the NMHC concentrations systematically increased during the day, reaching a value of 1068 ppb by 1500 PDT at El Rio. The aircraft flights showed substantial daytime increases of ozone up to a height of 1500 m in the interior of Santa Barbara County. Aircraft spirals offshore indicated that ozone concentrations of up to 150–200 ppb were encountered in the 200–400 m layer during the afternoon. This layer was cut off from the surface because it was very stable with limited vertical mixing.

During the morning of 24 September the surface ozone concentrations were not unusually large, but ozone concentrations of 60 ppb found at stations on elevated terrain, such as Laguna Peak, suggest that high ozone concentrations existed aloft. Moore et al. (1991) point out that the surface ozone concentration rapidly increased throughout the day, with exceedances of the ozone standard occurring at 1300 PDT at Santa Barbara and half a dozen sites in Ventura County. Most of these exceedances were found in the southeast corner of the SCCCAMP study region. By 1500 PDT the maximum ozone concentrations occurred in Santa Barbara County and western Ventura County with maxima of 180–200 ppb. Later the ozone maximum moved further west to the Santa Ynez airport.

On 24 September, CO concentrations at inland sites such as El Rio reached 1000 ppb during the afternoon, the highest reading during the whole episode. The chlorofluorocarbon-12 concentrations (an indicator of an urban air mass) also reached their highest levels during the afternoon of the 24th (800 ppt versus a regional background of 500 ppt). Similar peaks in several other inert tracers suggest that air from a distant region with higher background levels of these tracers may have been contributing to the local observed concentrations.

The ozone levels aloft increased substantially during 24 September from an initial 100 ppb to 150–200 ppb (Moore et al. 1991). Over land, the layer with the greatest ozone concentrations extended from the surface to a mixing height of about 800 m over Ventura County. Over water, the layer with high ozone concentrations extended from 100 to 500 m. At the water surface, observed ozone concentrations were not particularly high, suggesting that there was little downward mixing from the stable air mass aloft. During case study 3, as during case studies 1 and 2, ozone concentrations tended to be as high on coastal mountaintops as in nearby inland valleys and tended to be higher inland than offshore (see the ozone concentration time series in Fig. 4). Case studies 1 and 3 each showed shoreline ozone concentrations higher in the eastern part of the domain on the first day of the episode, followed by nearly equal values on the second day of the episode. Presumably this equalization was caused by the advection of pollutants from east to west due to easterly winds on the second day.

Tracers were released in the early morning of 24 September from an offshore oil platform in the western part of the region and from an aircraft at 600-m elevation over the San Fernando Valley (Strimaitis et al. 1991). By midmorning, the release from the offshore oil platform was advected onshore by southeasterly winds, and the release from the aircraft was carried to the west in the easterly wind flow evident in Fig. 11. The interpolated observed surface wind field pattern for this period does indicate south winds near the oil platform in the afternoon, in agreement with the observed tracer trajectory.

It can be concluded that case study period 3 was representative of an ozone episode in the SCCCAMP region. The episode began with a day dominated by a high pressure system with subsidence, clear skies, hot temperatures, and light winds. As a result, ozone concentrations increased due to local sources on the first day of the episode. However, advection from the eastern part of the region on the second day led to high

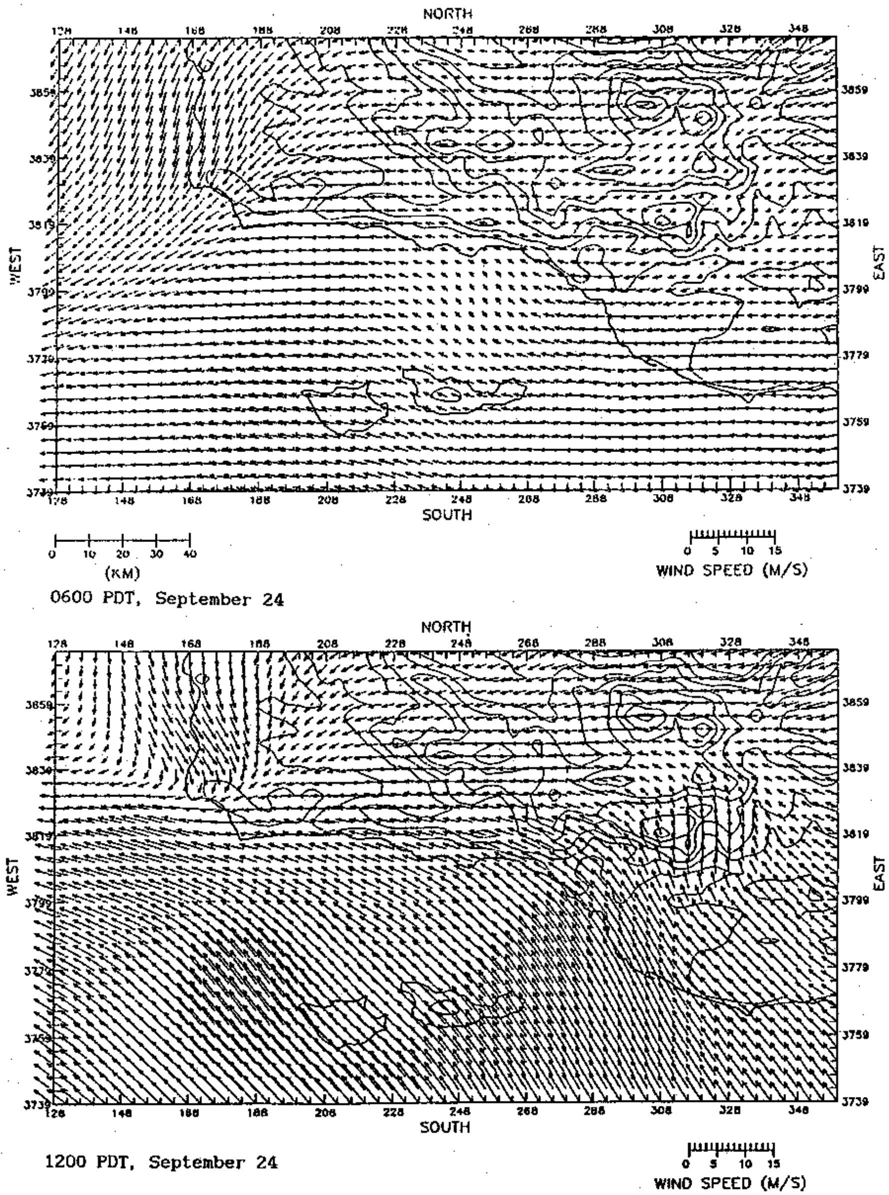

FIG. 11. Interpolated observed wind fields at an elevation of 300 m for 0600 (a) and 1200 (b) PDT on 24 September for the third case study period (from Kessler et al. 1989).

ozone concentrations resulting from emissions from a combination of local and distant sources. The advection occurred along both the coastal and inland paths and extended vertically to heights of several hundred meters. By the end of the episode, high ozone concentrations reached Santa Ynez, but did not penetrate very much into the Vandenberg/Lompoc area in the far western part of the region. The episode ended as clouds from Tropical Storm Terry entered the region.

6. Characteristics of case study 4, 2–4 October

The fourth case study period, on 2–4 October, was the most unusual of the four since very low mixing depths and easterly winds resulted in advection of pollutants from the Los Angeles basin out over the ocean and low-lying coastal plains. This advected air mass combined with local sources to cause ozone observations to exceed National Ambient Air Quality standards in the SCCCAMP region (see the ozone time series in Figs. 3 and 4). The highest concentrations of the entire SCCCAMP period were observed at most offshore and coastal stations during case study 4, and these high concentrations extended over the westernmost monitoring locations. Ozone concentrations were relatively low at inland and mountaintop monitors. As in the previous three case studies, this case study was associated with a tropical depression approaching from the south.

The surface weather map for 1700 PDT 3 October in Fig. 12 shows high pressure over the ocean to the northwest and a tropical depression over the ocean several hundred kilometers to the south. The cyclonic motion around the tropical depression is very evident in the satellite photograph, which suggests that a broad cloud bank exists just to the south of the SCCCAMP region. In fact, these clouds spread over the region on 4 October, causing increased vertical mixing (see the radiosonde time series in Fig. 5) and resulting in a reduction of ozone concentrations in the polluted air mass that had hugged the shoreline during the previous two days.

On 2 October dominant northwest winds persisted over the Vandenberg area and over the ocean off Point Arguello (Kessler et al. 1989). Farther to the east on this day the winds were light out of the northeast. The interpolated observed wind fields at a nominal height of 300 m are plotted in Fig. 13 for times of 0600 and 1200 PDT 3 October. As seen in the figure, on 3 October the entire domain was covered by winds with a component from the east, even overpowering the tendency towards northwest flow off Point Arguello. Coincidentally, this is the only day during the five-week SCCCAMP period that ozone concentrations exceeded 100 ppb at Vandenberg, at the far western edge of the domain.

Because the mixing heights were very low during the 2–4 October episode (Baxter 1991), there was a buildup of local emissions of halocarbons and hydrocarbons along the California coastal region on 2 October and on the coast and offshore on 3 October. An easterly wind early in the morning of 3 October appeared to move a large pool of polluted air trapped near the surface out into the ocean off Los Angeles. Moore et al. (1991) point out that aircraft observations on 3 October suggest that this reservoir of polluted air was then moved to the northwest by southeasterly winds during the day. According to surface ozone observations, this air mass extended at least as far southwest as San Miguel. Air chemistry observations suggest that substantial amounts of halocarbon-enriched air moved into the study region from the south at elevations of 100–200 m. Halocarbon (F_{12}) concentrations, which were found to have the least time or spatial variability of all the air chemistry measurements, nearly doubled from the nonepisode background values to rival those typically observed in Los Angeles (Hester et al. 1974). During 3 October the hydrocarbon speciation most closely resembled that of an urban environment (Moore and Killus 1991). However, the hydrocarbon data suggested that in addition to the aged urban component, there seemed to be a competing geogenic/fugitive component. The net result was that some of the largest $NMHC/NO_x$ ratios of all the episodes were observed.

Aircraft observations verified that this polluted air mass was shallow, extending only up to 200 m (Moore et al. 1990). In the late afternoon on 3 October the ozone-enriched air moved into the coastal regions of both Santa Barbara and Ventura counties. Because of the structure of the sea breeze on that day, the ozone-enriched air mass did not penetrate very far inland, and, therefore, did not significantly increase ozone concentrations aloft over the interior of either Santa Barbara or Ventura counties. High coastal ozone concentrations were observed by the aircraft along the entire coastline as far west as Point Conception.

As shown by Strimaitis et al. (1991), the observed movement of tracer clouds agreed with the above wind field and ozone interpretations, since the tracer clouds also tended to hug the coast and move generally from east to west. For example, the tracer clouds that were released from the surface near the Mandalay power plant and from platform C on the previous afternoon were observed along the shoreline between Gaviota and Point Dume in the early morning on 3 October. These clouds were being advected by the easterly flow, which was being augmented by the land breeze in the early morning.

It is concluded that the episode detected during case study 4 was primarily caused by the advection of a shallow mass of polluted air by easterly flow from the Los Angeles basin into the Santa Barbara Channel. High ozone concentrations over the water and along the shoreline were, therefore, mostly due to distant sources. Moderate ozone concentrations observed in inland valleys were probably due to local sources, since

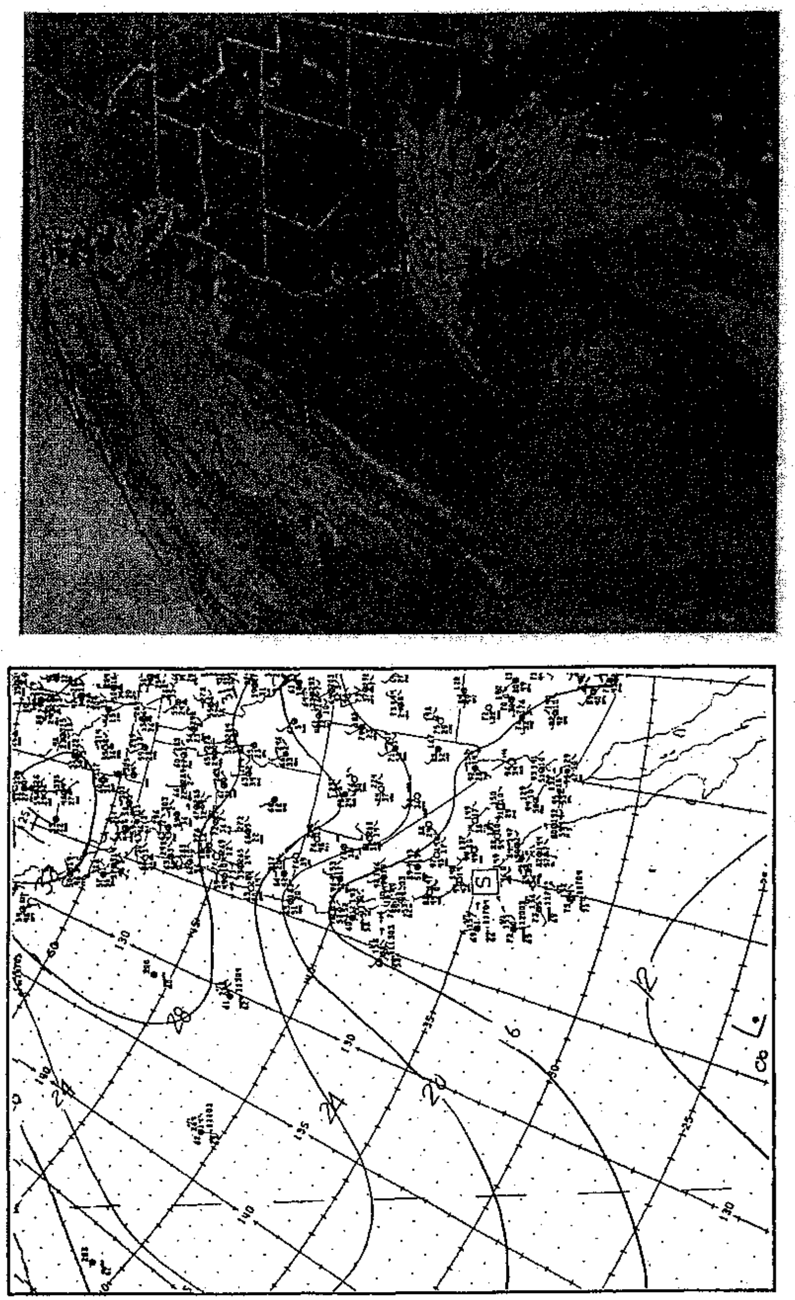

FIG. 12. Surface weather map (1700 PDT) and satellite photograph (2100 PDT, 4 km, IR) for 3 October 1985 (from Viezee et al. 1987). The SCCCAMP region is marked by an "S." The spiral of clouds around the tropical depression is seen in the satellite photograph.

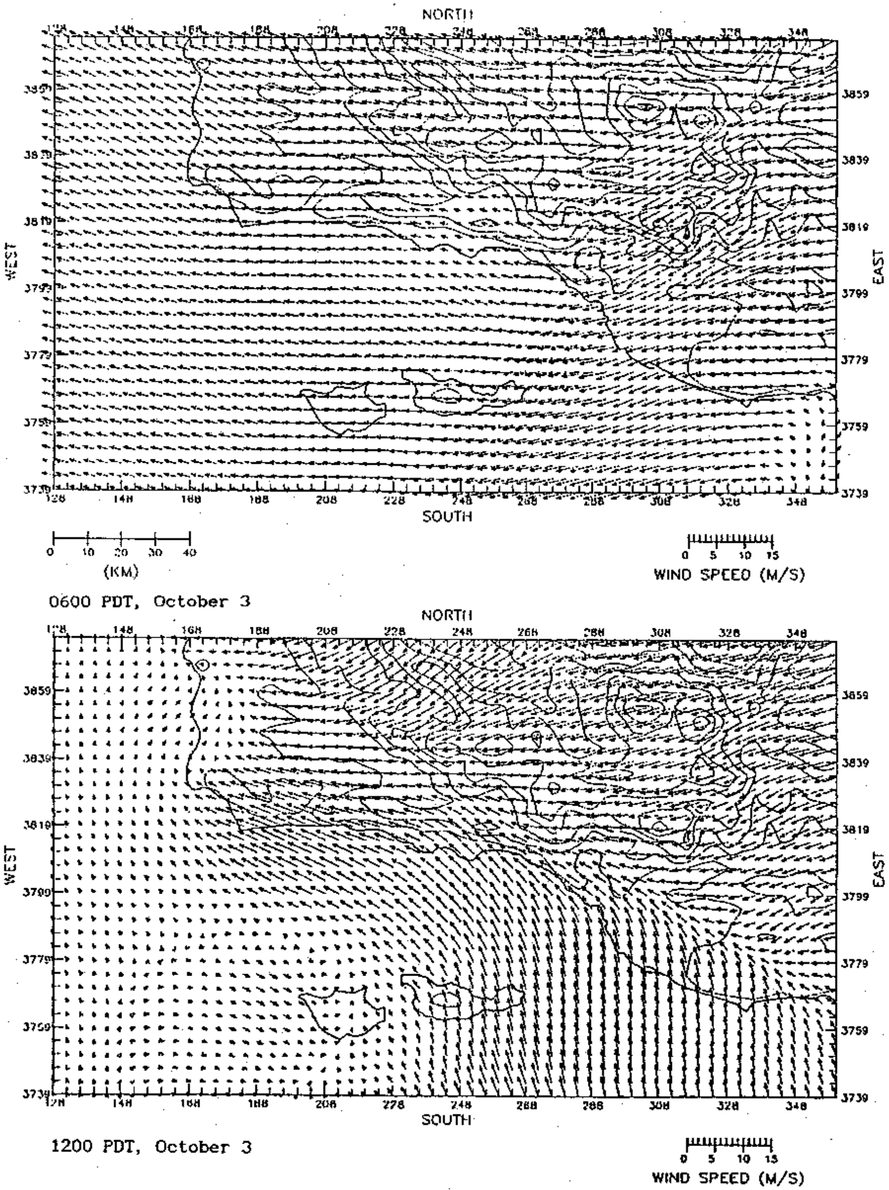

FIG. 13. Interpolated observed wind fields at an elevation of 300 m for 0600 (a) and 1200 (b) on 3 October for the fourth case study period (from Kessler et al. 1989).

the polluted air mass was not able to penetrate past the first coastal range.

7. Summary of four intensive case study periods

The previous sections have described the detailed results of the four intensive case study periods. A brief summary of each of the four intensive case study periods is given in the following text.

a. Case study 1, 11–13 September

The 120-ppb ozone standard was exceeded at some inland and mountaintop stations in Ventura County on 13 September. This case study is an example of an episode caused partly by the emissions from local sources when the region is under the influence of a stable high-pressure system, and partly by polluted air advected from source regions to the east (i.e., Los Angeles). Typical sea-breeze recirculation patterns existed on 12 September. This flow pattern was slightly perturbed on 13 September by a southeasterly flow in the eastern part of the region, resulting in the advection from the Los Angeles area of a pollution tongue with ozone concentrations of about 200 ppb at a height of 300–400 m above the surface. This polluted air mixed down to the surface in inland areas of Ventura County. The episode ended on 14 September as a cold front passed through the region.

b. Case study 2, 20–21 September

No ozone exceedances were observed during this case study, which was similar to the first case study, with the exception that no significant easterly flow developed aloft. A typical sea-breeze pattern was evident, as the region was influenced by high pressure. It appears that local sources dominated the observed ozone patterns.

c. Case study 3, 23–25 September

The third case study was actually a continuation of the second case study. Large exceedances of the ozone standard were observed throughout Ventura County and many parts of Santa Barbara County, as concentrations reached values of 200 ppb. An easterly flow developed during this case study, as the high pressure was slowly displaced by the northerly fringes of Tropical Depression Terry as it approached from the southeast. The easterly flow during case study 3 extended farther to the west and persisted for a longer time than during case study 1. However, the persistent northwesterly flow off Point Arguello was not perturbed during this case study. Furthermore, some evidence of the sea breeze was seen on each day. Again, the effects of local sources were compounded by a tongue of ozone-rich air that was advected along the coast and inland at elevations of 200–400 m. Observed ozone concentrations were nearly equal on coastal mountaintops and inland valleys. The episode ended on 25 September as clouds from Tropical Depression Terry spread over the region.

d. Case study 4, 2–4 October

This case study was unique in that very low mixing depths and easterly winds caused the advection of pollutants from the Los Angeles basin out over the ocean and low-lying coastal plains. There was no elevated tongue of pollutants at inland locations, as in case studies 1 and 3. As in previous case studies, this one began with strong high pressure, clear skies, and light winds; causing the buildup of pollutant concentrations due to local sources. By 3 October, easterly winds spread over the entire region, even overwhelming the northwesterly flow off Point Arguello. This is the only time during any of the case studies that high ozone concentrations extended as far west as Vandenberg. The ozone standard was exceeded at most offshore and coastal stations on that day. During the afternoon, a southerly sea-breeze perturbation developed that advected the polluted air mass into coastal areas. There is little question that this episode was caused mainly by advection of pollutants from the Los Angeles basin.

Acknowledgments. This report is based on analyses of the SCCCAMP 1985 data carried out by a number of scientists and has benefited from extensive technical reviews of oral and draft reports conducted by the SCCCAMP committee composed of over 20 scientists from various government agencies, industries, universities, and other research groups. We appreciate Mr. Thomas Chico's guidance as Minerals Management Service (MMS) Project Manager over the duration of this project. In addition, we appreciate the assistance of Mr. Roy Endlich, Mr. William Viezee, and their associates of SRI International in answering our questions concerning the SCCCAMP 1985 Data Archive.

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F...

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

December 5, 1996

Richard H. Baldwin
Air Pollution Control Officer
Ventura County Air Pollution Control District
669 County Square Drive
Ventura, CA 93003

Dear Mr. Baldwin:

Per a request from the U.S. Navy, I am writing to clarify the attainment classification status of San Nicolas and Anacapa Islands. We understand that the District's Air Pollution Control Board specifically exempted San Nicolas Island from the Air Quality Management Plan requirements, pending a formal determination from EPA that San Nicolas Island is not part of the Ventura County federal ozone nonattainment area.

As you know, Anacapa and San Nicolas Islands are part of Ventura County. However, the Ventura County ozone nonattainment area comprises all of Ventura County except for the Channel Islands, which are designated as unclassifiable/attainment in the South Central Air Basin. Therefore, although part of Ventura County, the Anacapa and San Nicolas Islands are not part of the Ventura nonattainment area. If you have any additional questions or comments, please contact Julia Barrow, Chief of the Planning Office, at (415) 744-1230.

Sincerely,

for

David P. Howekamp
Director
Air Division

cc: Lynn Terry, ARB
Scott Johnson, VCAPCD
Henry Hogo, SCAQMD
Hasan Jafar, US Navy, Pt. Mugu

Our Vision Clean Air

34604

Santa Barbara County
Air Pollution Control District

3/7/05

February 25, 2005

Lt. Ken Kusano (G-MSO-5)
US Coast Guard
2100 Second Street S.W.,
Washington, D.C. 20593-0001

Mr. Cy Oggins,
California State Lands Commission
100 Howe Ave., Suite 100-South,
Sacramento, CA 95825-8202

USCG-2004-16877-975

SUBJECT: SUPPLEMENTAL COMMENTS ON CABRILLO PORT DEEPWATER PORT LICENSE APPLICATION: DEIS/DEIR
Docket Number: USCG-2004-16877; State Clearinghouse Number: 2004021107

Dear Lt. Kusano and Mr. Oggins:

The Santa Barbara County Air Pollution Control District (District) provides this letter as a supplement to our comment letter, dated December 20, 2004, on the DEIS/DEIR referenced above. Our supplemental comments are based on new information of substantial importance discovered since the close of the public comment period on this project. The new information appears to be inconsistent with information provided in the DEIS/DEIR regarding the Environmental Setting of the proposed project.

The District is concerned about the potential for this project to import liquefied natural gas (LNG) that does not meet the current California Air Resources Board (CARB) specifications (i.e., LNG that contains higher BTU content levels of ethane, propane, and butane) for compressed natural gas (CNG) for use in motor vehicles. A recent study conducted by Southern California Gas Company (Gas Quality and LNG Research Study Draft Final Report dated 2-11-05) states that LNG sources originating in areas such as Indonesia, Russia, and Australia differ from natural gas currently supplied to southern California from out-of-state domestic sources as some ethane, propane and butane have been removed from out-of-state domestic natural gas prior to shipment via interstate pipelines. (An excerpt from this study is attached for your convenience.) If correct, this finding is inconsistent with Section 4.6.1 that states that the LNG to be imported for the project will meet pipeline quality specifications (including CARB specifications) without further treatment at the offshore storage and regasification unit. This conflicting information leads us to believe that the project could indeed import LNG that does not meet CARB specifications and, if so, the DEIS/DEIR should address this important issue.

The importation of LNG into southern California that does not meet California's CNG specifications creates a potential for increased regional emissions from both stationary and mobile sources. In fact, the recent Southern California Gas Company study shows a strong correlation between increased NOx emissions and higher BTU content test gases for various residential/commercial gas appliances. The DEIS/DEIR should address how this could impact existing regional emission levels. We strongly recommend that all imported LNG meet CARB motor vehicle fuel specifications for CNG in order to ensure that there are no increases in regional emissions from the importation of LNG. Further, since it appears that it is foreseeable

Terence E. Dressler • Air Pollution Control Officer
260 North San Antonio Road, Suite A • Santa Barbara, CA • 93110 • www.sbcapcd.org • 805.961.8800 • 805.961.8801 (fax)

that this project may import such "hot" gas, the District also believes that your commission must address the issue of whether recirculation of the DEIS/DEIR is required under CEQA.

Again, we appreciate the opportunity to comment on the DEIS/DEIR for this important project. If you need additional information on these comments please call me at 805.961.8857.

Sincerely,

Tom Murphy

Tom Murphy
Manager, Technology and Environmental Assessment

cc: TEA Chron File
Bobbie Bratz, Santa Barbara County Air Pollution Control District
William Dillon, Deputy County Counsel
Martin Kay, South Coast Air Quality Management District
Scott Johnson, Ventura County Air Pollution Control District
Alison Dettmer, California Coastal Commission

Attachment

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The Need to Reduce Marine Shipping Emissions: A Santa Barbara County Case Study

Paper # 70055

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ABSTRACT

Marine shipping, the largest unregulated source of oxides of nitrogen (NOx) emissions, represents a significant long-term obstacle to achieving ozone standards in coastal areas, as documented in the example of Santa Barbara County in California.

According to the Santa Barbara County Air Pollution Control District (APCD) 2001 Clean Air Plan, 1999 base year NOx emissions from marine vessels were more than those from all on-road motor vehicles, and comprised just over a third of the total NOx emissions inventory. By 2015, the Plan projects that NOx emissions from ships will be almost five times greater than those from on-road motor vehicles, and comprise more than 60 percent of the total NOx emissions inventory.

The projected increase in marine shipping emissions essentially negates all the NOx emissions reductions expected to occur onshore, and brings the 2015 inventory to levels close to those experienced in 1999, the year Santa Barbara County attained the federal one-hour ozone standard. This jeopardizes the county's ability to maintain the ozone standard. Achieving reductions in marine shipping emissions is critically important for the county's long-term air quality, especially as it is increasingly difficult to obtain cost-effective onshore emission reductions.

Since more than ninety percent of the NOx emissions from vessels transiting offshore the county fly foreign flags, and the existing fleet has a slow rate of turnover, the task of reducing marine shipping emissions is a challenging one. While regulatory approaches may achieve NOx emission reductions over the long term (10-30 years), incentive programs and partnerships to reduce emissions from existing vessels are essential for continued air quality improvements in the near term (1-10 years).

This paper provides information about the Santa Barbara County emissions inventories, places this information in a national and international context, outlines the existing regulatory framework, identifies opportunities for near-term cost-effective emission reductions, and highlights the need for incentives and partnerships to gain momentum in reducing marine shipping emissions through demonstration programs. Much of what we have learned and will present is thanks to the work of others who have been researching this issue for many years. And while this paper presents Santa Barbara County specific data, we believe that the information is germane to other areas of the nation and internationally.

INTRODUCTION

There is a growing awareness internationally of the significance of shipping emissions. Ships are increasing in number, size, carrying capacity and speed, while fuel use is increasing proportionally.[1,2,3,4] In addition, residual heavy fuel oil – the most common fuel used in large ship engines – is decreasing in quality, while a greater number of engines are being designed to use this lower-quality fuel.[5]

There is also an increasing awareness of the impacts of shipping emissions on onshore air quality. An estimated 85 percent of international shipping traffic occurs in the northern hemisphere, and 70 percent of that is within 400 km (240 miles) of land.[6] Much of the shipping activity and associated emissions occur near major urban areas, many of which are already struggling with air quality problems.

There is a range of estimates for NOx emissions from marine shipping activities. The United States Environmental Protection Agency (USEPA) estimates that approximately 4.4 percent of total NOx emissions in the United States come from compression ignition marine engines.[7] One study estimates that NOx emissions from US ships are 127,000 tons/year (inland rivers) and 317,000 tons/year (ocean-going).[8] According to a study conducted for USEPA in 1991, ocean-going marine vessel emissions contributed more than 11 tons per day of NOx in New York/New Jersey and 19 tons per day of NOx in the Houston/Galveston area.[9] A recent estimate of year 2000 NOx emissions from ocean-going vessels in the Vancouver, B.C. region is close to 15 tons per day of NOx.[10] NOx emissions from ocean-going ships in the South Coast Air Basin for the year 2000 are estimated at 35 tons per day.[11]

Santa Barbara County is situated on the west coast of California between San Luis Obispo County to the north and Ventura County to the east. Even though Santa Barbara County does not have a port, more than 33 tons per day of NOx were produced by marine shipping activities offshore the county in 2000 – a figure more comparable to those estimated for Los Angeles and San Francisco. This is due to several factors. There is a very high volume of vessels transiting along the Santa Barbara County coastline, and most of these vessels use large, higher polluting, two-stroke engines. The county also has 130 miles of coastline, so these vessels are traversing a relatively long distance. In addition, much of the emissions associated with shipping activities occur between 10 to 20 miles from shore, as ships traverse the California coastline and/or use great circle routes throughout the Pacific Rim.

Santa Barbara County is currently classified by USEPA as a "serious" nonattainment area for the federal 1-hour ozone standard but has applied for redesignation as an attainment area. APCD developed a 2001 Clean Air Plan to support the application for redesignation, and to demonstrate continued attainment of the 1-hour standard for at least 10 years after redesignation.[12]

Based on accepted methodologies for estimating marine vessel emissions, primarily as detailed in the 1999 ARCADIS emissions inventory report,[13] inventories developed for Santa Barbara County's 2001 Clean Air Plan showed that marine shipping emissions represented approximately one-third of estimated NOx emissions for 1999. Marine shipping was thus the single largest source of NOx emissions, contributing an amount comparable to the NOx emissions from all trucks, cars, and buses operating onshore. In the 2015 emissions forecast, marine shipping emissions represent more than 60 percent of NOx emissions and are almost five times greater than those from on-road motor vehicles. The dramatic increase in NOx emissions from this source through the planning horizon essentially negates anticipated NOx reductions onshore from local, state and federal air programs. This also jeopardizes APCD's ability to show continued attainment of the federal 1-hour standard through 2015.

Data collected to calculate marine shipping emissions offshore Santa Barbara County during 2000 reveal several specific points of interest: [14]

- 6,424 total transits occurred offshore the county (an average of almost 18 transits every day of the year)
- 1,363 different individual vessels transited the coastline
- 91 percent of the emissions were from foreign-flagged vessels
- 10 percent of the individual vessels contributed 50% of the emissions
- 44 of the vessels each emitted more than 50 tons per year of NOx.

In Santa Barbara, we have assigned the moniker "frequent flyers" to those vessels that create the most emissions each year, due to a combination of the emissions characteristics of their engines, the fuel they burn, and the number of transits they make each year. One very interesting feature is that 10 percent of the ships make up 50 percent of the marine shipping emissions offshore Santa Barbara. The fact that a relatively small number of ships contributes a large percentage of emissions provides a unique opportunity to obtain significant emission reductions with retrofit technologies.

Efforts to regulate the emissions from marine shipping have been largely ineffective to date. More stringent regulations, and a more intensive focus on international implementation, are needed to encourage the development of engines that will be substantially cleaner than those already on the market today.

While regulatory efforts are of critical importance to reducing emissions in the long term, near-term strategies must also be pursued. The California Air Resources Board (CARB) has initiated the Maritime Working Group to provide a forum for discussion of air quality issues and concerns pertaining to maritime activities in California. This group draws upon a large group of interested parties including USEPA, local California air districts, port representatives, ship owner/operators, the Maritime Administration, engine manufacturers and emission control technology providers. Preliminary estimates indicate that implementing retrofit emission control technologies on existing ocean-going vessels could provide very cost-effective emission reductions relative to those already implemented onshore. The status of current efforts to reduce emissions from the existing vessels, and the need to continue to build partnerships to address this large source of emissions, will be discussed in this paper.

MARINE SHIPPING EMISSIONS INVENTORY

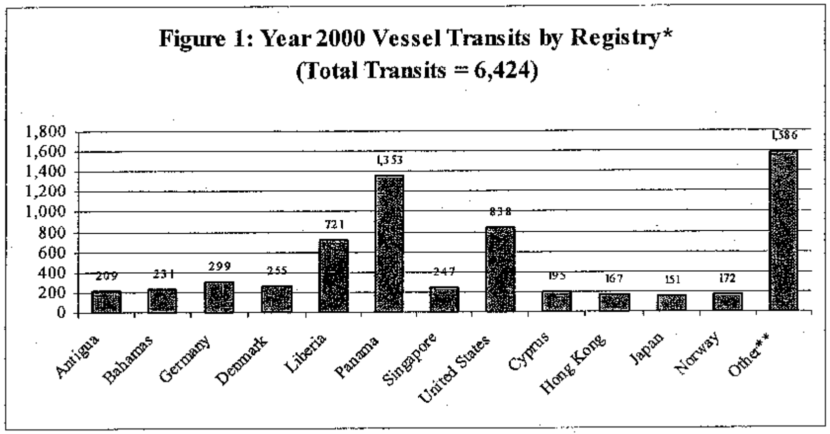
The NOx emissions from marine shipping activities offshore Santa Barbara County are largely due to three principal factors:

- There is a high volume of transits along the Santa Barbara County coastline.
- The majority of the vessels use large, higher polluting, two-stroke engines.
- The county has 130 miles of coastline, so these vessels are traversing a relative long distance. Much of this travel is through the Santa Barbara Channel, which is only 10-20 miles from the shore.

A detailed, ship-by-ship review was used to estimate emissions from ships transiting offshore Santa Barbara. The inventory process gathered information on ship names, arrival and departure dates and direction, ship type (e.g., container, bulk carrier), flag, dead-weight tonnage, and average cruise speed. Port Hueneme[15] and the Marine Exchange of Los Angeles - Long Beach Harbor, Inc.[16] were the main sources of these data.

All ships that arrived from the north to Port Hueneme, the Port of Los Angeles or the Port of Long Beach, or departed to the north from any of these ports, were included in the estimates. Duplicates were eliminated. The average cruising horsepower for each ship's main engine(s) was determined using methods detailed in the ARCADIS report, or by consulting the Lloyd's Registry of Ships.[17] Emissions from auxiliary engines were included. We determined the Santa Barbara coastline transit time for each ship, and applied NOx emission factors from the ARCADIS report. The factors used were based on ARCADIS' analysis of NOx emissions limits finalized in late 1997 at the International Maritime Organization, and considered emissions testing of ships performed as part of Lloyd's Marine Exhaust Emissions Research Programme.[18]

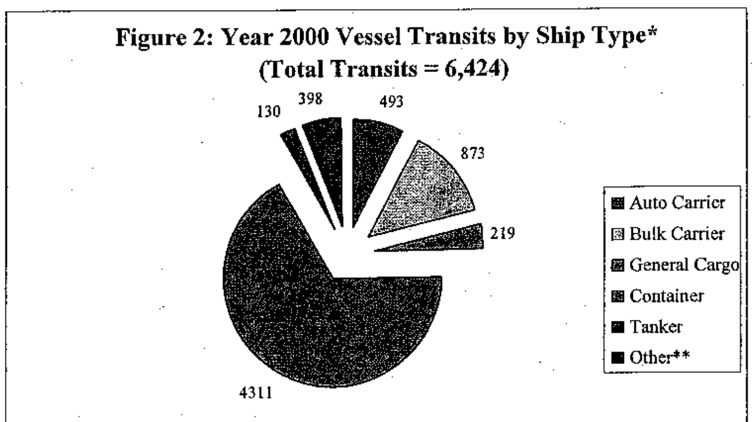
Figure 1 presents a summary of the number of transits along Santa Barbara during 2000 by vessel registry.



*2000 Marine Exchange Data – Ports of Los Angeles/Long Beach.
**Comprised of 37 other countries.

During the year 2000, there were 6,424 vessel transits along Santa Barbara County from 49 different countries. The country with the greatest number of vessel transits was Panama (1,353 transits), followed by the United States (838 transits), and Liberia (721 transits). More than 87 percent of the total transits along this coastline were by foreign-flagged vessels.

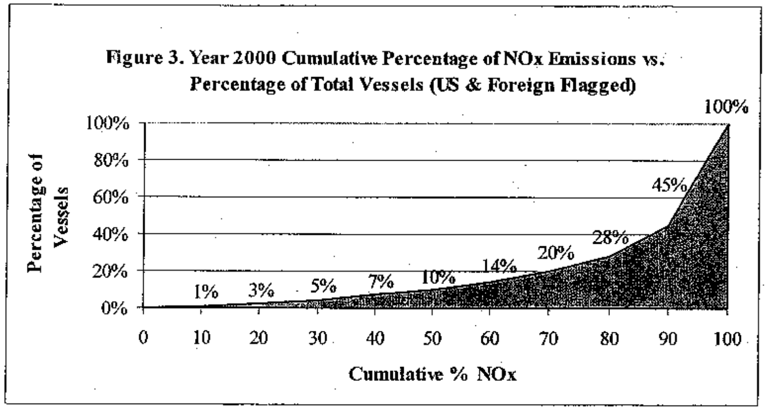
Figure 2 itemizes the types of vessels that traversed our coastline during 2000.



* 2000 Marine Exchange Data – Ports of Los Angeles/Long Beach.
** Other vessels include Passenger, Reefer, and Ro-Ro vessels.

Figure 2 shows that 67 percent of the 6,424 traverses along our coastline in the year 2000 were by container vessels, followed by bulk carriers (14 percent), auto carriers (8 percent), general cargo vessels (3 percent), and tankers (2 percent).

Figure 3 shows a comparison of the cumulative percentage of NOx emissions versus the percentage of vessels for 2000 offshore Santa Barbara.



Source: 2000 Marine Exchange Data, Ports of Los Angeles/Long Beach

This figure shows that by focusing our retrofit efforts on only 10 percent of the vessels that transit along our coastline, we can target 50 percent of the NOx emissions associated with shipping activities impacting our air quality.

Table 1 presents the maximum and average horsepower ratings by vessel type for those vessels that traversed our coastline during 2001.

Table 1: Maximum and Average Horsepower Ratings by Vessel Type[19]

Vessel Type	Maximum Horsepower	Average Horsepower
Auto Carrier	20,940	10,430
Bulk Carrier	20,874	7,742
Container Ship	109,600	32,322
General Cargo	57,089	7,738
Passenger	62,370	30,913
Reefer	15,079	11,267
Ro-Ro	26,921	11,056
Tanker	29,422	8,778

Table 1 shows that the container vessel fleet averaged 32,000 horsepower with a maximum horsepower rating of 109,000. General cargo and passenger vessels had maximum horsepower ratings around 60,000 with the remaining vessels maximum horsepower ratings ranging from 20,000 to 30,000.

The combination of the large number of vessel transits along our 130-mile coastline and the high percentage of container vessels that have the highest average and maximum horsepower ratings (equating to higher emissions) resulted in more than 33 tons per day of NOx emissions in the area in 2000. Foreign-flagged vessels accounted for 87 percent of the total transits, but accounted for 91 percent of the total NOx emissions, since these vessels are predominantly large, higher emission container ships.

SHIPPING EMISSIONS IN THE CONTEXT OF SANTA BARARA COUNTY AIR QUALITY PLANNING

APCD has prepared several air quality plans for Santa Barbara County to comply with state and federal ozone standards, and offshore emissions have been considered significant in these documents for some time. The first two plans, the 1979 Air Quality Attainment Plan and the 1982 update were prepared in response to mandates established by the federal Clean Air Act Amendments of 1977. The 1982 update predicted attainment of the federal ozone standard by 1984, but acknowledged that the county's ability to attain the federal ozone standard was uncertain because pollution generated offshore was not considered.

In the 1994 Clean Air Plan, photochemical air quality modeling was performed for the region. This modeling showed that emissions from marine shipping activities contributed to ozone formation, and found that Santa Barbara County would attain the federal 1-hour ozone standard by the mandated 1996 attainment date but for the emissions generated off the coast by marine shipping activities.[20]

Santa Barbara County was unable to attain the federal 1-hour ozone standard by the 1996 attainment deadline, and was reclassified in 1997 as a "serious" nonattainment area by the USEPA. The new classification required additional regulatory requirements and the development of another air quality plan to show attainment by a new deadline of November 15, 1999.

Subsequent to the development and submission of the next air quality plan (1998 Clean Air Plan) required to comply with the "serious" nonattainment area mandates, air quality monitoring data showed that the county met the federal 1-hour ozone standard by the 1999 attainment deadline. This prompted the development of a "Maintenance Plan," which became the 2001 Clean Air Plan.

The Maintenance Plan required APCD to determine an "attainment inventory" for Santa Barbara County against which to compare future predicted emissions through 2015. Since the federal 1-hour ozone standard was attained from 1997 through 1999, emission inventories were developed for 1999 for both reactive organic compounds (ROC) and NOx.

The attainment inventory methodology assumes that the emission levels experienced in Santa Barbara County during 1999 are adequate to keep measured ozone concentrations below the federal 1-hour ozone standard. The maintenance demonstration must show that predicted future year emission levels through 2015 are below the attainment inventory established for 1999.

2001 Clean Air Plan Emission Inventory

This section describes the baseline emission inventory used in the development of the 2001 Clean Air Plan. The emission inventory accounts for the types and amounts of pollutants emitted from a wide variety of sources, including on-road motor vehicles and other mobile sources, fuel combustion at industrial facilities, solvent and surface coating usage, consumer product usage, and emissions from natural sources. Emission inventories are used to describe and compare contributions from air pollution sources, evaluate control measures, schedule rule adoptions, forecast future pollution, and demonstrate attainment and maintenance of air quality standards.

Emission Inventory Development

The emission inventory is organized in a three-tier hierarchy that categorizes all air pollution sources. The first tier of this hierarchy contains four divisions:

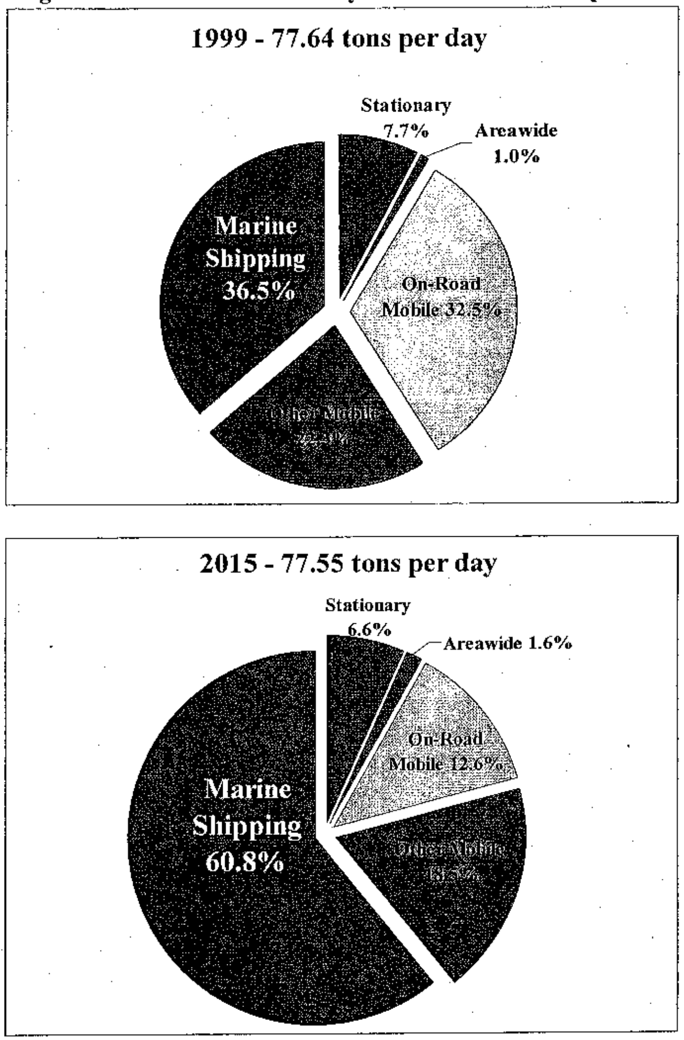
- Stationary sources (e.g., internal combustion engines, boilers, mineral processing)
- Area-Wide sources (e.g., consumer products, paints and solvents)
- Mobile sources (e.g., cars, trucks, planes, trains, ships)
- Natural sources (e.g., vegetation, oil and gas seeps).

In the second tier, each of the four divisions is sub-divided into major source categories. The third tier divides the major source categories into summary categories. For the purposes of this paper, we present NOx emissions by first tier emission divisions for stationary, area-wide, and mobile sources both onshore and offshore of Santa Barbara County, with marine shipping emissions distinguished from the "other mobile" sources. Natural sources are not included in this paper as those emissions are not human-generated.

1999 and 2015 Emission Inventories

Once the 1999 emission inventory was developed using the most current data, it was forecast out to 2015 using both growth and control assumptions. Growth assumptions include changes in population, employment, vehicle miles traveled, agricultural acres in use, and many others. Control assumptions predict the expected emission controls that will result from local, state and federal air programs. The combination of both growth and control data assumptions are applied to the 1999 inventory in order to develop the 2015 forecast. Figure 4 presents the emission inventories developed for 1999 and forecast for 2015.

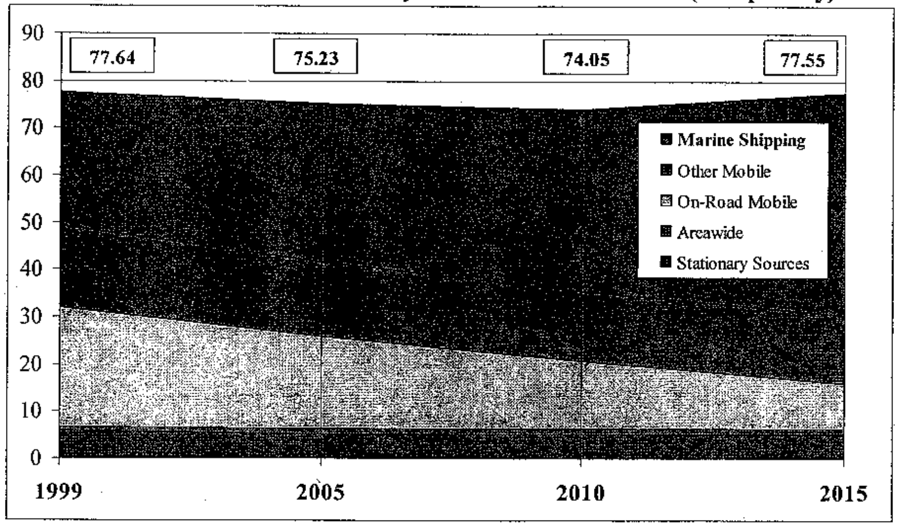
Figure 4: Santa Barbara County NOx Emissions Comparison



As seen in Figure 4, marine shipping activities contribute more NOx emissions to Santa Barbara County than all the cars, trucks, and buses operating onshore, and represent 36 percent of the total NOx emissions in 1999. The figure also shows that marine shipping emits more NOx than all the "other mobile" sources in the county, including trains, planes, off-road vehicles, farm and construction equipment and many other sources. In addition, Figure 4 shows that the anticipated growth of marine shipping emissions results in a NOx emission contribution of 60 percent of the total inventory by 2015, almost five times the emissions associated with on-road motor vehicles.

Figure 5 presents the forecast for NOx emissions from 1999 through 2015.

Figure 5: Santa Barbara County Forecast NOx Emissions (tons per day)



This figure shows that total NOx emissions decline slightly from 1999 through 2010 and then increase through 2015 to levels that approach those experienced during 1999. This figure also documents that the projected increase in marine shipping emissions essentially negates all the NOx emissions reductions expected to occur onshore from local, state and federal air programs.

IMPLICATIONS FOR MEETING AIR QUALITY STANDARDS

Since forecasted NOx emission levels in 2015 are approaching those experienced in 1999, the county's maintenance demonstration to USEPA comes under increasing scrutiny. If marine shipping emissions continue at the projected rates without any additional controls, Santa Barbara County's long-term trend of improving air quality and ability to maintain attainment of standards could be jeopardized.

Marine shipping activities are the most significant source of emissions that impact our local air quality. And the fact that the growth of marine shipping emissions is counteracting the emission reductions achieved onshore via regulatory controls is of greatest concern. Local, state and federal air programs, in existence for more than 30 years, have resulted in significant emission reductions to date and are anticipated to provide additional emission reductions into the future, as Figure 5 illustrates.

However, the issue at hand is that the majority of the cost-effective emission controls available onshore have been implemented or are already scheduled for implementation. Additional onshore controls will be difficult to obtain and expensive to implement. Reducing emissions from marine shipping activities is of critical importance to the long-term air quality of Santa Barbara County.

REGULATORY FRAMEWORK

Although the shipping industry is highly regulated in some environmental areas such as sewage and waste, and ballast water, regulatory efforts to date to reduce air emissions from marine shipping have not kept pace with emission reduction programs onshore. MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships. Annex VI, adopted by the Parties to MARPOL in 1997, has NOx requirements for the Category 3 engines typically used in ocean-going vessels, beginning January 1, 2000. This Annex has not been ratified by the required minimum of 15 member countries representing 50 percent of the world's merchant shipping.

However, since the NOx emission standards contained in Annex VI are retroactive to January 1, 2000 once the Annex is ratified, virtually all ship engine manufacturers already build engines that meet these standards. No additional emission reductions from ratification of Annex VI are expected, although ratification does represent a first step toward the implementation of additional technology-forcing standards and requirements in the future.

The USEPA Final Rule on Control of Air Pollution from New Marine Compression-Ignition Engines at or Above 37 kW (50 hp), effective 1/28/2000, applies to Category 1 and 2 engines, and recommends that the IMO adopt regulations for Category 3 engines that are more stringent than the Annex VI requirements. In 2000, the Bluewater Network settled a lawsuit against the USEPA for failure to establish standards for Category 3 engines. The settlement required USEPA to establish standards for these engines by January 2003. The resultant regulation recently promulgated by USEPA establishes standards that are no more stringent than those established in Annex VI.[21]

CARB is currently developing proposed emission control strategies for commercial marine vessels and ports that are expected to become part of the South Coast Air Quality Management District's State Implementation Plan.[22] These strategies will provide emission reductions statewide. Measures under consideration include:

- setting more stringent emission standards for new harbor craft and ocean-going ships;
- developing ways for existing harbor craft fleet to use cleaner engines and fuels;
- designing strategies to clean up the existing ocean-going fleet; and
- taking steps to reduce land-based emissions at ports.

Action on the state's proposed measures is expected between 2003 and 2005, with implementation in the 2003-2010 timeframe.

Even in the best-case scenario—if new regulations are adopted by CARB and USEPA, and the IMO moves to strengthen standards under Annex VI— it could be many years before significant emission reductions are realized through the regulatory process, particularly for the larger ocean-going vessels that traverse the Santa Barbara coastline. Most of the USEPA and IMO regulations only apply to newly manufactured vessels. Since the turnover of vessels is very slow, coastal and port areas will be living with pollution from existing vessels for many years. Therefore, it is imperative to develop partnerships and incentive programs like those being evaluated by CARB, and to initiate demonstration projects to reduce emissions from the existing vessels that transit our area.

TECHNOLOGIES

Until recently, many have viewed shipping industry emissions as fairly minor, of lesser impact to onshore air quality, and difficult, if not impossible, to control. Over time, these views have changed in recognition of the facts that a significant percentage of total man-made emissions are from ships, these emissions have both near-shore and regional air quality impacts, and feasible technologies are available at reasonable costs to clean up ship emissions.[23]

Most NOx emissions in exhaust gases are produced due to high temperatures during the combustion process. There are primary methods to reduce NOx formed during combustion, most of which attempt to reduce the maximum temperatures during combustion, as well as secondary methods that treat the post-combustion exhaust gas stream to reduce NOx. Examples of each method are shown below:

Primary:

- Engine related: injection timing retard, higher compression ratios, increased charge air
- Fuel injection: nozzle changes and injection rate shaping
- Addition of water: fuel-water emulsion, direct water injection, pre-treatment of combustion air (humid air motor or combustion air saturation systems)
- Exhaust gas recirculation

Secondary:

- Selective catalytic reduction (SCR) mixes exhaust gas with ammonia or urea before it passes through a catalytic bed
- Electrostatic precipitators to reduce PM emissions
- Oxidation catalysts to reduce CO and HC
- Low-sulfur content fuel that allows catalytic converters

In addition to the noted control technologies, operational limits that reduce emissions can also be implemented. The voluntary speed reduction program that limits the speed of ships entering the Ports of Los Angeles and Long Beach is an example of setting operational limits to achieve emission reductions.

Both primary and secondary control technologies are applied most easily to a specific ship during the ship's design stage. Application of these technologies as retrofit controls (i.e., not as part of a ship's original design) has potential downsides, including: high unit cost; ship downtime for installation of the new controls; increased fuel use (typical for timing retard and water injection or emulsion systems); the need for large amounts of deionized water production and storage (typical for water injection, emulsion, and humid air motor systems); potential engine damage from the control system (possible with exhaust gas recirculation that routes exhaust gas particulate matter through the charge air system); and lack of space on the existing ship (e.g., installing SCRs on 2-stroke engines).

In addition, significant modifications to an engine not previously subject to the NOx Technical Code of MARPOL 73/78 of Annex VI may make the engine subject to the Annex VI requirement to demonstrate that the modifications did not cause an increase in emissions. This means that pre- and post-modification emissions tests may be required, even for engines not previously subject to Annex VI requirements.

Table 2 presents a summary of various retrofit control technologies that could be installed on large vessel engines.[24]

Table 2: Performance Attributes Summary of NOx Control Technologies for Existing Engines.

Control Technology	Nominal NOx Reduction (%)	Nominal Reduction in PM and other Pollutants (%)	Nominal Increased Fuel Use (%)	Net Present Value ($)	Global Cost Effectiveness ($/ton NOx)
Aftercooler upgrade	10	-1	2	$184,000	$620
Engine derating	14	-10	4	$386,000	$933
Fuel pressure increase	14	-21	2	$220,000	$523
Injector upgrade	16	-21	2	$192,000	$410
Injection Timing Retard	19	-11	4	$363,000	$618
Water in combustion air	28	1	3	$365,000	$468
Exhaust gas recirculation	34	-51	0	$16,900,000	$16,377
Water/fuel emulsion	42	15	2	$325,000	$284
Selective catalytic reduction	81	0	0	$475,000	$227

As this table shows, a range of control technologies can be evaluated as retrofits to existing vessels in order to reduce NOx emissions, and these controls potentially carry a lower cost per ton of emission reduction than most typical onshore emission controls. In addition, focusing retrofit efforts on the "frequent flyer" vessels that create the most emissions will provide the most cost-effective emissions reduction projects.

A review of cost-effectiveness calculations for incentive programs,[25] generation of emission reduction credits,[26] and emission control measures[27] shows a range of cost from $660 to more than $40,000 per ton of NOx reduced. By way of comparison, the average cost per ton for industrial NOx emission reduction credits used in Santa Barbara County from 1999 through 2003 was more than $9,000, and the average cost per ton from California's Carl Moyer Program (Years 1 and 2) was $5,000.

Comparatively, emission reduction programs for marine shipping applications have the potential to produce significant levels of emission reductions on a more cost-effective basis. This is due to the fact that onshore emission reduction programs have matured, while marine shipping emissions have been largely unregulated to date.

However, the cost-effective emission reductions from marine shipping require a large capital expenditure as indicated by the Net Present Value costs associated with the technologies identified in Table 2 that range from $184,000 to several million dollars. A broad-based partnership/incentive approach will be necessary to support capital expenditures of this magnitude, and provide for the evaluation, implementation and verification of these technologies though demonstration programs. Once a technology or set of technologies is proven, additional funding partnerships and incentives will be needed to expand implementation programs to other existing vessels.

Table 2 also highlights the potential for increases in other pollutants (e.g., particulate matter, greenhouse gases) and decreased fuel efficiency. These trade-offs need to be clearly identified and minimized to the greatest extent feasible. For example, injection timing retard generally reduces NOx emissions, but increases PM, and increases fuel use with an associated increase in greenhouse gas emissions. A thorough review of each emissions reduction technology must be conducted for each application to avoid emission trade-offs that may be counter to broader clean air goals.

Fuel characteristics can also be modified to reduce pollution, primarily by reducing sulfur content, thereby reducing SOx emissions, and allowing the use of catalytic treatment of exhaust gases to reduce NOx. SOx emissions reduction is a major concern in much of Europe, due to the impacts of acid rain.[28, 29]

There is a tremendous opportunity to reduce both SOx and NOx emissions by reducing the sulfur content of fuels used in shipping. The current average sulfur content of heavy fuel oils used by large marine vessels is about 2.5% (25,000 ppm). The fuel sulfur content limits of the impending IMO Annex VI are set at 4.5% (45,000 ppm), with a 1.5% (15,000 ppm) limit for SOx Emissions Control Areas (SECA) such as the Baltic Sea. Upon application to IMO after Annex VI is implemented, other areas (e.g., coastal areas of the United States) may be declared SECA areas with the 1.5% sulfur limit. These sulfur content values contrast with the current California on-road diesel limit of 0.05% (500 ppm), especially as the sulfur content of typical on-road diesel fuel is usually well below this limit, generally in the 130-150 ppm range. Also, ultra low sulfur diesel (15 ppm sulfur) is now becoming available, and will soon be required on both urban buses and solid waste collection vehicles in California. This ultra low sulfur diesel requirement will also apply nationwide for on-road diesel fuel starting in 2007, so it is clear that there are opportunities to improve the quality of the fuels used by the shipping industry.

The above tables and information document the fact that many opportunities exist to achieve emission reductions from existing marine vessels. Steps towards implementation of a demonstration program targeting reductions from existing vessels could include:

- Identification of funding sources, and securing of funding;
- Design of emissions-testing protocols to validate emission reductions;
- Selection of candidate vessels for demonstration projects;
- Development of criteria for judging the success of a demonstration retrofit program;
- Testing of emission-control technologies in real-world use;
- Evaluation of these technologies for widespread use;
- Formulation of a plan for widespread implementation.

However, as previously outlined, due to the significant capital investment required, the development of creative partnerships and innovative strategies is necessary to build momentum for the implementation of retrofit technologies and cleaner-fuels strategies.

PARTNERSHIPS AND INCENTIVES

The Maritime Air Quality Working Group (MWG), led by CARB, is an industry-wide group of stakeholders including air agencies (CARB, USEPA, and local air districts), environmental groups, and shipping industry representatives (owner operators, ship captains, major engine manufacturers, technology vendors and marine consultants). The group's goal is to gain a basic understanding of the shipping industry, identify control technologies that can reduce NOx and PM emissions from ship engines, and determine how to make these technologies attractive for both retrofit and new implementation by carriers.

The MWG has had several meetings over the last year that have incorporated presentations on available and developing control technologies, and the group is currently reviewing vendor proposals to demonstrate retrofit control technologies on ship engines at sea. The APCD participates in this working group and is interested in seeing cost-effective control technologies successfully installed on one or two ships over the next year.

The US Department of Transportation Maritime Administration (MARAD) is pursuing in parallel a program to review, select, install, demonstrate and test emissions of retrofit control technologies for reducing NOx emissions of large ship engines. MARAD is investigating possible incentive programs to encourage control technology installation on coastal vessels, and will determine if these technologies increase combustion efficiency, thereby saving fuel and reducing greenhouse gases. It is likely that the MARAD demonstration will be the first partnership project for the MWG stakeholders.

Business for Social Responsibility (BSR) is a consortium of businesses interested in improving the environmental and social impact of their operations, and of their suppliers. Among many other programs, BSR has formed a Clean Cargo Program to encourage the ship owner operators – their "carriers"- to reduce emissions from their sea transport operations.

A range of incentive programs that could be evaluated include:

- Emission reduction credits – A system in which credits are provided for reducing vessel emissions that can be traded within a market-based system.
- Differential port fees – A system where cleaner vessels pay lower fees and dirtier vessels pay higher fees with a net result equal to the existing fee structure.
- Government incentives – Similar to California's Carl Moyer Program in which funds are allocated to cost-effective projects, based on the merits of the project and the level of cost share funding.
- Environmental award programs – A system in which cleaner vessels are provided the recognition and positive publicity for being the cleanest of the fleet.
- Preferential port access – A system in which the cleanest vessels have the best access to port facilities.

These types of incentive programs need to be carefully evaluated as part of the effort to reduce emissions from the existing fleet. Without some type of incentive program, the information and experience gained in retrofit demonstration projects may not be realized due to the large capital costs associated with many of the technologies discussed in this paper.

It is important to coordinate efforts toward understanding the dynamics of the shipping industry, and researching and demonstrating control technologies by building partnerships, evaluating incentive programs, and sharing results. Only with a cooperative, partnership-based approach will we realize emission reductions from the existing vessels that transit along the Santa Barbara coastline and other areas nationally and globally.

CONCLUSIONS

As documented in the Santa Barbara County emissions inventories, marine shipping emissions currently impact onshore air quality, and, if left uncontrolled, will be of increasing concern in the future. Conclusion points of interest are listed below.

- Marine shipping emissions are significant and largely unregulated locally, nationally and globally.
- If marine shipping emissions continue to increase without controls, they may threaten attainment strategies of coastal (and inland) areas. This could increase the need to reduce emissions onshore, where many of the most achievable and cost-effective reductions have either already been obtained or are in process.
- International and national regulatory efforts have been largely ineffective to date, and should be strengthened to set targets for development of new engine technologies.
- While regulatory strategies are important to reducing these emissions in the long term, a near-term strategy is needed for existing vessels.

- Many control technologies are available that can potentially reduce emissions in the near term from existing marine vessels at a relatively low cost per ton of NOx reduced. In fact, these technologies are significantly more cost-effective than typical onshore emission controls.
- Retrofit of existing vessels with emission controls will demand a high capital expenditure.
- A coordinated partnership-based approach will be necessary to support the capital expenditure, and provide for the evaluation, implementation and verification of retrofit technologies though demonstration programs.
- Once a technology or set of technologies is proven, additional funding partnerships and incentives programs will be needed to expand implementation programs with existing vessels.

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KEY WORDS

Marine Shipping, Marine Shipping Emissions, Compression Ignition Engines, Air Pollution Control, Santa Barbara County, Annex VI, Emission Control Technologies, Clean Air Plans, Container Ships

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6.0 AIR QUALITY IMPACT ANALYSIS

INERT POLLUTANTS

An Air Quality Impact Analysis (AQIA)* is required when the following conditions are met:

1. Non-attainment pollutants (NSR Review).

   If that portion of a stationary source within APCD jurisdiction has a net emissions increase (NEI) greater than 5 pounds per hour but less than 10 pounds per hour, 240 pounds per day or 25 tons per year of non-attainment pollutants, an AQIA will be required which must show no violation or interference with attainment. In addition, if that portion of the stationary source within APCD jurisdiction has an NEI of greater than 10 pounds per hour, 240 pounds per day or 25 tons per year of non-attainment pollutants, an AQIA will be required to determine compliance with all ambient air quality standards.

2. Attainment Pollutants (PSD Review).
   An AQIA is required when:

   A. Project has components located within a Class 1 or Class 1 impact area and the NEI for that portion of stationary source within APCD jurisdiction is greater than 20 pounds per hour of CO or 5 pounds per hour for other attainment pollutants.

   B. The emissions from the entire stationary source is greater than 20 pounds per hour for an attainment pollutant. (Note that the emissions from the entire source, not the NEI is used for this determination.)

In A and B above, no ambient air quality standard can be exceeded.

<u>Location of Sources to be Included in AQIA</u>

To be included in the AQIA are all emissions from the stationary source. This includes facilities in the OCS and outside of Santa Barbara County which have the potential to impact Santa Barbara County air quality, and all facilities within the jurisdiction of the APCD.

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* The term AQIA is used in this document to mean Air quality Impact Analysis under NSR rules and "modeling" under PSD rules.

Sources to be included in the AQIA may be expanded if project conditions placed on the applicant by other regulatory agencies direct that other scenarios be examined by the APCD. Examples of additional issues for which analysis may be required include, but may not be limited to:

1. Air quality impacts from consolidated facilities.

2. Cumulative air quality impacts from proposed project and all reasonably foreseeable projects.

3. Air quality impacts from construction emissions.

4. Future specific throughput rates or levels of production not applied for by the applicant.

General Flow of AQIA:

1. Establish baseline air quality through minimum of one year of pre-construction monitoring (PCM).

2. Model to determine air quality impacts from the emissions of the proposed stationary source and source expansion emissions from permitted sources which were not operating at permitted capacity during the applicant's year of PCM.

Compliance with Ambient Air Quality Standards:

The results of the AQIA analyses are to be compared to all Local, State and Federal Ambient Air Quality Standards and increments.

Modeling Methodology for AQIA:

The following protocol is to be used for establishing air quality impacts for sources of emissions included in the AQIA.

INERT POLLUTANT MODELING METHODOLOGY:

I. Introduction

A. Models

For inert pollutant modeling, the models which are to be implemented are as follows:

COMPLEX-II: For modeling inert pollutant impacts from all onshore point sources which impact terrain with elevation equal to or greater than the height of the lowest stack height.

MPTER: For modeling inert pollutant impacts from all point sources which impact terrain with elevation less than the height of the lowest stack height.

TURNER FUMIGATION: For modeling inert pollutant impacts under fumigation conditions from onshore and offshore point sources of emissions.

ISCST: For modeling inert pollutant impacts from onshore non-point sources of emissions.

OCDCPM: For modeling inert pollutant impacts from offshore sources and coastal (up to 1 km from shoreline) point sources associated with offshore sources of emissions.

Table 6-I-1 provides some generic project scenarios and the associated modeling requirements. The primary function of the Table is to show the differences between onshore and offshore sources. Onshore point sources (dependent upon terrain) require the use of either MPTER or COMPLEX II. The only exception to this requirement is if the onshore point source is directly linked to an offshore source (i.e., a processing plant onshore supplied by an offshore platform). Under this circumstance, OCDCPM can be used for both onshore and offshore sources. It must be noted that the onshore source in question must be within one kilometer of the shoreline to be modeled with OCDCPM. All onshore construction activities will be modeled with ISCST and summed with all concurrent point source emissions. Fumigation modeling will be executed for all pollutant sources except onshore construction activities. All offshore pollutant sources are considered point sources.

TABLE 6-I-1
GENERIC PROJECT SCENARIOS AND REQUIRED MODELING RUNS

	MPTER	COMPLEX II	OCDCPM	ISCST	FUMIGATION
Offshore point source	N/A	N/A	Required	N/A	Overwater version required
Onshore point source	Required according to receptor heights	Required according to receptor heights	N/A	N/A	Overland version required
Onshore point source* directly linked to offshore point source	N/A	N/A	Required	N/A	Both overland and overwater versions required
Onshore point source with concurrent offshore activity	Required for onshore source as above	Required for onshore source as above	Required for offshore activity **	N/A	Both overland and overwater versions required
Onshore construction activities	N/A	N/A	N/A	Required ***	N/A

NA = Not Available

* Onshore source within one kilometer of shoreline.

** Results will be summed with concurrent MPTER or COMPLEX II results.

*** Construction impacts will be summed with any other concurrent modeling results.

Additional Notes:

All offshore pollutant sources are considered point sources.

In order to assess cumulative air quality impacts from different source types, modeled pollutant concentrations from point sources and non-point sources which impact the same receptor during a given hour are to be summed together. This will require the use of a post-processor program and modification to the code of the model(s) used to output concentrations in a format acceptable to the post-processor. The District can provide information on this post-processor program and the required modification to the model(s) used.

In all instances fumigation modeling is to be performed in addition to the other modeling analyses prescribed in this protocol.

B. Source of Models

MPTER and ISCST are available from the National Technical Information Service (NTIS). MPTER and ISCST are part of a library of air quality simulation models titled "User's Network for Applied Models of Air Pollution - version 6" (UNAMAP 6) (USEPA, 1986).

Fumigation models are available from the California Air Resources Board (CARB). A document titled "Users Guide to the California Air Resources Board Air Quality Modeling Section Fumigation Models" is available free from the ARB which lists the codes and test cases for two fumigation models (Wagner, 1984). The Fumigation Model code is for assessing fumigation impacts from onshore sources, and the Coastal Fumigation Model code is for assessing fumigation impacts from offshore sources. The ARB will send a magnetic tape containing the two fumigation models to those requesting it for a handling fee. Fumigation models are also available from the District.

OCDCPM and COMPLEX II are available on magnetic tape from the District.

C. Submittals to APCD

Upon completion of the model runs, the applicant must provide the APCD on hard-copy and magnetic tape all material leading to and including the final output(s). This would include, but not be limited to, all input files, control files, output files, pre- and post-processor programs and their input, output and control files, and all models used. In short, supply all the information needed to duplicate the work submitted by the applicant. Tape format should be 9-track, ASCII, unlabeled, 1600 BPI, specified record length and 10 records per block.

II. Modeling of Point Source Emissions with COMPLEX-II

A. Option Specifications

Option Specifications: 0 = Don't Use Option

1 = Employ Option

OPTION		
	TECHNICAL OPTIONS	
IOPT (1)	Use Terrain Adjustments	1
IOPT (2)	No Stack Downwash	0
IOPT (3)	No Gradual Plume Rise	0
IOPT (4)	Use Buoyancy Induced Dispersion	1
	INPUT OPTIONS	
IOPT (5)	Met. Data is on Cards	0
IOPT (6)	Read Hourly Emissions	0
IOPT (7)	Specify Significant Sources	0
IOPT (8)	Input Radial Distances and Generate Polar Coordinate Receptors	0
	PRINTED OUTPUT OPTIONS	
IOPT (9)	Delete Emissions with Height Table	1
IOPT (10)	Delete Resultant Met. Data Summary for Avg. Period	1
IOPT (11)	Delete Hourly Contributions	1
IOPT (12)	Delete Met. Data on Hourly Contributions	1
IOPT (13)	Delete Final Plume Height and Distance to Final Rise on Hourly Contributions	1
IOPT (14)	Delete Hourly Summary	1
IOPT (15)	Delete Met. Data on Hourly Summary	1
IOPT (16)	Delete Final Plume Height and Distance to Final Rise on Hourly Summary	1
IOPT (17)	Delete Averaging - Period Contributions	1
IOPT (18)	Delete Averaging - Period Summary	1
IOPT (19)	Delete Average Concentrations and High-Five Table	0
	OTHER CONTROL AND OUTPUT OPTIONS	
IOPT (20)	Run is Part of a Segmented Long Run	0
IOPT (21)	Write Partial Concentrations to Disk or Tape	0
IOPT (22)	Write Hourly Concentrations to Disk or Tape	0
IOPT (23)	Write Averaging - Period Concs. to Disk or Tape	0
IOPT (24)	Punch Averaging - Period Concentrations on Cards	0
IOPT (25)	Complex Terrain Option	1

Discussion:

IOPT (25) does not apply to MPTER.

The above option specifications are those which should be used for submittal to the District. Should the applicant wish to employ option specifications other than those listed above which do not affect the concentration calculations, they may do so with proper notification of the District prior to making the modeling runs.

The actual height of wind speed measurement (anemometer height or ANHT) should be used as input. In most cases this will be 10 meters.

Exponents for power law wind speed increase with height are:
0.10, 0.15, 0.20, 0.25, 0.30, 0.30

Terrain Adjustments are:
0.5, 0.5, 0.5, 0.5, 0.0, 0.0

ZMIN is 10.0

With regard to the length of the air quality and meteorological data set to be used in the AQIA, the minimum data set will be the year of applicant pre-construction monitoring. In addition, the APCD may require that any other available air quality and meteorological data which are deemed appropriate be included as input in the AQIA.

B. Meteorology

Meteorological parameters required by COMPLEX-II are wind speed, wind direction, temperature, stability class and mixing height. Hourly wind speed, wind direction and temperature should at a minimum be obtained from the previously approved APCD pre-construction monitoring activities for the project in question. The pre-construction monitoring and other data used as input to the Air Quality Impact Analysis must be of at least one year duration. Stability class is to be obtained in a manner consistent with the EPA document "Guideline on Air Quality Models, Revised" (USEPA, 1986). Twice daily mixing heights are available from Pt. Mugu and Vandenberg. Hourly mixing heights can be estimated from pre-processing programs such as those available for CRSTER (USEPA, 1977). If twice daily mixing heights are not available, hourly mixing heights can be estimated from (Holzworth, 1972).

C. Source Parameters

For each source of pollutants modeled, the following inputs are required: source coordinates (UTM), emission rate, stack height, stack gas temperature, stack gas velocity and source elevation. All of these parameters must be reviewed by the APCD engineering staff prior to executing the model.

Maximum hourly emission rates are to be used for modeling averaging periods less than or equal to 24 hours.

Annual average emission rates are to be used for annual average concentration calculations.

Emission rates used as input to the models are to be the proposed emission increases from the stationary source. All emission increases from the source which have occurred or will occur after the pre-construction monitoring data are collected must be included. Additionally, emissions from other permitted sources which were not operating at permitted capacity at the time of pre-construction monitoring must be included in the modeling.

To the extent possible, offsets will be included in the AQIA. If the source(s) to be used as offsets were operating during the air quality pre-construction monitoring period, then the contribution of the offset source(s) to the background air quality values used in the AQIA may be considered for being "backed out" of the appropriate air quality background value. "Backing out" is to be considered only if it can be determined that the offset source(s) impacted the air quality monitor(s) during the time period when the background air quality value(s) used in the AQIA were measured. Contact District staff for guidance on this matter.

If the source(s) to be used as offsets were modified so as to incorporate offset emissions strategy during the year of pre-construction monitoring for air quality, then no further consideration on the incorporation of offsets in the AQIA is necessary.

D. Use of background Air Quality for Pollutants Other Than NO_2.

The values for background air quality for pollutants requiring modeling must be accomplished in the pre-construction monitoring phase of the project prior to performing the AQIA. Background air quality values will be added to project impacts for comparison to ambient air quality standards.

Background air quality is to be added to project impacts as follows:

1. Using the year of pre-construction monitoring meteorological data as input to the model, determine the maximum modeled concentration for each pollutant and averaging period in question.

2. Review the year of pre-construction monitoring air quality data to determine the maximum ambient air quality values measured for each pollutant and averaging period in question.

3. For each pollutant and averaging period, add the results of steps 1 and 2 to obtain the total pollutant concentration which is to be compared with ambient air quality standards.

E. Use of Background Air Quality for NO_2

The ozone - limiting method is to be used to convert modeled NO_x concentrations to NO_2 concentrations (Cole and Summerhays, 1979).

<u>Procedure</u>:

1. One-hour NO_2

   A. Using the year of pre-construction monitoring meteorological data as input to the model, determine the maximum one-hour NO_x concentrations (NOXMAX).

   B. Review the year of pre-construction monitoring air quality data to determine the maximum simultaneous hourly sum of ozone plus NO_2.

   C. Assume that ten percent of the NO_x emissions are in the form of NO_2 at the stack.

D. Compare the remaining NO_x (0.9 * NOXMAX) to the ozone concentration during the hour which contained the maximum sum of ozone plus NO_2. If the ozone concentration is greater than 0.9 * NOXMAX, then total conversion to NO_2 is assumed (NOXMAX = NO_2). If not, then the NO_2 concentration is set equal to the ozone concentration and added to the stack NO_2 portion.

```
IF (0.9 * NOXMAX .LE. CHIO3) THEN
   CHINO2 = NOXMAX

ELSE

   CHINO2 = 0.1 * NOXMAX + CHIO3

ENDIF
```

E. The calculated NO_2 concentration resulting from the source is then added to the NO_2 concentration during the hour which contained the maximum sum of ozone plus NO_2.

F. Compare the value obtained in E to the one-hour CAAQS for NO_2.

2. Annual NO_2

A. Using the year of pre-construction monitoring meteorological data as input to the model, determine the maximum annual NO_x concentration.

B. Assume 100 percent conversion of NO_x to NO_2.

C. Add the resultant NO_2 concentration obtained in B to the annual average ambient NO_2 value obtained from the applicant's year of pre-construction monitoring air quality data.

F. Receptor Grid Spacing

Receptor points shall be placed as follows:

1. At 250 meter intervals on a cartesian grid.

2. At specific discrete points to ensure that maximum potential impact is modeled (for example - on facility boundary line, or on sub-grid size terrain features). Receptor grid should be large enough in extent to cover region(s) of significant impact(s).

3. Receptors shall not be placed inside applicant's facility boundaries. Receptors are to be placed starting at discrete points along the facility boundary line or along an arc 100 meters away from the nearest source(s), depending on whichever distance is greater from the source(s) in question.

4. Receptor elevations are to be obtained from 7.5 minute USGS or more detailed topographic maps.

III. Modeling of Point Source Emissions with MPTER

The information which applies to COMPLEX-II also applies to MPTER, with the following exceptions:

1. MPTER is to be used for receptors which are at lower elevation than the lowest stack height being modeled.

2. IOPT (25) does not apply to MPTER.

IV. Fumigation Modeling

Fumigation modeling is also to be done for the CAAQS for one-hour NO_2 and one-hour SO_2.

Review the year of pre-construction monitoring meteorological data to determine examples of worst-case meteorology. All cases of E and F stability and low wind speeds (less than or equal to 3 meters per second) should be examined. Wind speeds too low to transport offshore sources to shore after 3 hours travel at that speed are to be increased to necessary speed to reach shore within 3 hours.

Use actual wind directions associated with the above cases.

Depending on source locations, use either or both of the ARB fumigation models discussed earlier (Wagner, 1984).

Use same source parameters, ozone - limiting method, and/or background air quality considerations as for COMPLEX-II/MPTER.

V. Modeling of Onshore Non-Point Source Emissions

A. General Information

This section outlines the Santa Barbara County Air Pollution Control District (District) protocol for modeling air quality impacts from onshore non-point source type emissions (volume and area sources). This protocol is specifically designed to be applicable to the following types of emission sources:

1. Onshore construction combustive emissions (NO_x, PM-10, SO_2, CO)

   a. Site preparation and grading

   b. Facility installation and assembly

   c. Pipeline right of way (ROW) preparation, trenching and installation

   d. All other combustive emissions prior to facility operation

2. Onshore construction fugitive emissions (PM-10)

   a. Site preparation and grading

   b. Facility installation

   c. Pipeline ROW preparation and trenching

   d. All other ground-disturbing activities

3. Onshore operational fugitive emissions (ROC, H_2S)

   This category includes fugitive emissions from valves, flanges, connections and any other venting of ROC to the atmosphere.

4. Onshore operational fugitive emissions (TSP, PM-10)

   a. Fugitive dust from excavation (mine pits), stockpiles and graded areas

   b. Fugitive dust from unpaved roadways and parking lots

   c. Fugitive dust from material transport - such as uncovered haul trucks, railways

d. Fugitive dust from material handling - such as uncovered conveyors, crushers, hoppers, screens, etc.

This protocol is designed to cover the majority of scenarios which are anticipated to be analyzed by the District. However, should a particular scenario include components which are not covered in this protocol, the District will determine the appropriate procedures to be used in the Air Quality Impact Analysis.

The air quality model to be used for the above identified scenarios is the Industrial Source Complex Short-Term model (ISCST). ISCST is to be used for all pollutants and for all averaging periods, including annual. This model is available from the National Technical Information Service (NTIS) as part of the library of air quality dispersion models titled "User's Network for Applied Models of Air Pollution - Version 6 (UNAMAP 6). ISCST is also available from the District.

B. ISCST Option Specifications

This section discusses the values to be specified for each option used by ISCST.

1. ISW Option Specifications:

Option	Option List	
1.	CALCULATE (CONCENTRATION=1, DEPOSITION=2)	ISW(1)=1
2.	RECEPTOR GRID SYSTEM (RECTANGULAR=1 OR 3, POLAR=2 OR 4)	ISW(2)=1 OR 3
3.	DISCRETE RECEPTOR SYSTEM (RECTANGULAR=1, POLAR=2)	ISW(3)=1
4.	TERRAIN ELEVATIONS ARE READ (YES=1, NO=0)	ISW(4)=0 OR 1
5.	CALCULATIONS ARE WRITTEN TO TAPE (YES=1, NO=0)	ISW(5)=0
6.	LIST ALL INPUT DATA (NO=0, YES=1, MET DATA ALSO=2) COMPUTE AVERAGE CONCENTRATION (OR TOTAL DEPOSITION) WITH THE FOLLOWING TIME PERIODS:	ISW(6)=1
7.	HOURLY (YES=1, NO=0)	ISW(7)=1
8.	2-HOUR (YES=1, NO=0)	ISW(8)=0

Option (Con't)	Option List	
9.	3-HOUR (YES=1, NO=0)	ISW(9)=1
10.	4 HOUR (YES=1, NO=0)	ISW(10)=0
11.	6 HOUR (YES=1, NO=0)	ISW(11)=0
12.	8-HOUR (YES=1, NO=0)	ISW(12)=1
13.	12-HOUR (YES=1, NO=0)	ISW(13)=0
14.	24-HOUR (YES=1, NO=0)	ISW(14)=1
15.	PRINT 'N'-DAY TABLES(S) (YES=1, NO=0) PRINT THE FOLLOWING TYPES OF TABLES WHOSE TIME PERIODS ARE SPECIFIED BY ISW(7) THROUGH ISW(14):	ISW(15)=1
16.	DAILY TABLES (YES=1, NO=0)	ISW(16)=0
17.	HIGHEST & SECOND HIGHEST TABLES (YES=1, NO=0)	ISW(17)=1
18.	MAXIMUM 50 TABLES (YES-1, NO=0)	ISW(18)=1
19.	METEOROLOGICAL DATA INPUT METHOD (PRE-PROCESSED=1, CARD=2)	ISW(19)=1 OR 2
20.	RURAL-URBAN OPTION (RURAL=0 URBAN MODE 1=1, URBAN MODE 2=2)	ISW(20)=0
21.	WIND PROFILE EXPONENT VALUES (DEFAULTS =1 USER ENTERS=2, 3)	ISW(21)=1
22.	VERTICAL POTENTIAL TEMPERATURE GRADIENT VALUES (DEFAULTS=1; USER ENTERS=2, 3)	ISW(22)=1
23.	SCALE EMISSION RATES FOR ALL SOURCES (NO=0, YES IS GREATER THAN 0)	ISW(23)=var.[1]
24.	PROGRAM CALCULATES FINAL PLUME RISE ONLY (YES=1, NO=2)	ISW(24)=2
25.	PROGRAM ADJUSTS ALL STACK HEIGHTS FOR DOWNWASH (YES=2, NO=1)	ISW(25)=2
26.	PROGRAM USES BUOYANCY-INDUCED DISPERSION (YES=1, NO=2)	ISW(26)=2

Option (Con't)	Option List	
27.	PROGRAM USES A CALM WIND PROCESSING ROUTINE TO CALCULATE CONCENTRATIONS DURING CALM PERIODS (YES=1, NO=2)	ISW(27)=2
28.	PROGRAM SETS REGULATORY DEFAULT FEATURES (YES=1, NO=2)	ISW(28)=2
29.	PROGRAM ASSUMES SO_2 IS BEING MODELED (YES=1, NO=2)	ISW(29)=1 OR 2
30.	PROGRAM USES AN INPUT DEBUG MODE (YES=1, NO=2)	ISW(30)=1 OR 2
31.	NUMBER OF SOURCE GROUPS (=0, ALL SOURCES)	NGROUP=0
32.	TIME PERIOD INTERVAL TO BE PRINTED (=0, ALL INTERVALS)	IPERD=0
33.	SOURCE EMISSION RATE UNITS CONVERSION FACTOR	TK=.10000E+07
34.	ENTRAINMENT COEFFICIENT FOR UNSTABLE ATMOSPHERE	BETA1=0.600
35.	ENTRAINMENT COEFFICIENT FOR STABLE ATMOSPHERE	BETA2=0.600
36.	HEIGHT ABOVE GROUND AT WHICH WIND SPEED WAS MEASURED	ZR=var.[1]
37.	LOGICAL UNIT NUMBER OF METEOROLOGICAL DATA	IMET=5
38.	DECAY COEFFICIENT (0=DEFAULT)	DECAY=0
39.	ACCELERATION DUE TO GRAVITY (0=DEFAULT)	G=0
40.	SOURCE EMISSIONS OPTION	QFLG=0
41.	WIND SPEED CATEGORIES (0=DEFAULT)	UCATS=0

[1] value varies with scenario simulated.

ISW(31)
Flow-vector specific building widths + heights

DISCUSSION:

The above option specifications are those which should be used for submittal to the District. Should the applicant wish to employ option specifications other than those listed above which do not affect the concentration calculations, they may do so with proper notification of the District prior to making the modeling runs.

ISW(1): This option is to be set to 1 as only concentrations are to be calculated. No gravitational settling or deposition is to be considered.

ISW(2): This option can be set to 3 if the user wishes ISCST to create a portion of the receptor grid.

ISW(4): For modeling ground-based area and volume sources, ISW(4) is to be set to 0 with terrain elevations not read into the model.

For modeling elevated (non-ground based) volume sources, terrain elevations can be read into the model (ISW(4)=1 if the lowest effective height of emissions is greater than any of the surrounding terrain being modeled (Note: Since plume rise is not considered in ISCST for area and volume sources, the effective height of emissions is equivalent to the release height of the emissions). Terrain elevations less than the lowest effective height of emissions are to be unaltered, however, terrain elevations greater than or equal to the lowest effective height of emissions are to be set equal to 0.1 meter less than the lowest effective height of emissions. This approach provides for an offset distance between the plume and the surrounding terrain and prohibits the termination of execution of ISCST if the elevation of any receptor is greater than or equal to the effective height of emissions of any volume source. As an alternative, the elevated volume sources may be modeled as ground-based volume sources with terrain not read into the model.

Scenarios which contain both ground-based and elevated volume sources can be modeled separately and the results assumed cumulative. As an alternative, all of the volume sources may be modeled as ground-based volume sources with terrain not read into the model.

For modeling scenarios which contain only area sources, ISW(4) is to be set to 0 as ISCST does not consider terrain effects for area sources.

For modeling scenarios which contain both area and volume sources (either ground-based and/or elevated) terrain is to be considered as if the scenario contained only volume sources.

In all cases in which terrain is not read into the model (ISW(4)=0), the elevations of the sources above mean sea level (ZS) are to equal 0. In cases in which terrain is read into the model ISW(4)=1), the actual values of source elevation (ZS), effective height of emissions (HS) and the terrain elevations (GRIDZ(IJ) are to be input in meters. Again, all values of GRIDZ(IJ) must be less than the sum of ZS + HS for any source.

ISW(7) through ISW(15): For those averaging periods for which concentrations are required, specify the option as equal to 1.

ISW(19): This option can equal 1 or 2 depending on the format of the meteorological data input file.

ISW(23): This option is to be set to 3 if only certain hours of a day are to be modeled. Refer to Section D.1. (Hours of Operation and Averaging Period considerations) for method of application in conjunction with QTK. QFLG is to equal 0.

ISW(24) and ISW(25): These options do not affect area and volume sources.

C. ISC Modeling for Specific Source Types

ISCST has the ability to simulate three source types: point (stack), area and volume. The District, however, sanctions the use of ISCST only for non-point source emissions types.

For each source, the following parameters are required as input: emission rate, coordinates (UTM or relative to user origin), elevation of source above mean sea level, height of source of emissions above ground surface, initial vertical dimension (volume sources only) and initial horizontal dimension. Specific information on the appropriate source parameters is discussed in this section.

1. Volume Sources (ITYPE =1)

As a rule, sources with emissions containing an initial vertical extent are to be modeled as volume sources. The initial vertical extent may be due to plume rise or a vertical distribution of numerous smaller sources over a given area.

Emissions which are to be modeled as volume sources include those resulting from construction combustive activities (NO_x, PM-10, SO_2, CO) and operational fugitive emissions (ROC, TSP, PM-10) which emanate from numerous levels covering the same ground surface area.

a. Emission Rate (Q)

The emission rate for volume source emissions is to be specified in grams/second (g/s). The worst-case one-hour emission rate is to be used for all averaging periods, except for annual average which will utilize an annual average emission rate. All emission rates are to be calculated in a manner consistent with district approved procedures.

With respect to modeling combustive PM-10 emissions, the following PM-10/TSP ratios are to be used in the absence of more specific information (ARB, 1987):

i. Stationary IC engines - diesel: 0.96

ii. Stationary IC engines - gas: 0.99

iii. Vehicular Sources -diesel: 0.96

iv. Vehicular Sources - gas: 0.99

b. Height of Source Above Surface (HS)

i. Construction Combustive Emissions

Combustive emissions from construction activities are to be modeled as ground-based volume sources (HS=0).

ii. Operational fugitive Emissions

ROC fugitive emissions emanating from numerous levels covering the same ground surface area are to be modeled as a volume source, with the height of emissions (HS) being set equal to the lowest level of the ROC fugitive emissions.

c. Initial Vertical Dimension (SIGMA-Z0, input as TS)

i. Constructive Combustive Emissions

The vertical dimension of a ground-based volume source is to equal the mass emission weighted plume rise of all the combustive sources contained within the volume source being modeled. The vertical dimension of a ground-based volume source is to be calculated in the following manner:

1. Each individual source within the volume source being modeled is to be examined. Utilize either the MPTER, or COMPLEX-II model with IOPT(14), IOPT(15) and IOPT(16) set equal to 0. Refer to Section II.A. for the specification of the remaining model options. This specification of these options will provide the user with information on final plume height for each source. For ground-based volume sources, the final plume height is equal to the final plume rise. Final plume rise is to be used for the purposes of calculating the vertical dimension of the volume source.

2. To determine the mean plume rise from the individual sources in the volume source being modeled, the following anticipated reasonable worst-case meteorological conditions are to be utilized:

   F Stability class; 1.0 meter/second wind speed

   F Stability class; 1.5 meter/second wind speed

   F Stability class; 2.0 meter/second wind speed

   For each individual source contained in the volume source, the mean of the plume rises associated with the above meteorological conditioned is to be calculated.

   $$hm_i = (h_i(F, 1.0)+ h_i(F, 1.5)+ h_i(F, 2.0))/3$$

3. For each individual source contained in the volume source, the mean plume rise is to be weighted by the emissions rate of the source (in grams/second). This is to be done by multiplying the mean plume rise by the emission rate on a source-by-source basis.

   $$MWPR_i = hm_i * Q_i$$

4. Sum the products of mean plume rise and emission rate for each of the sources contained in the volume source.

$$\sum_{i=1}^{N} MWPRi$$

5. Sum the emission rates for each of the sources contained in the volume source.

$$\sum_{i=1}^{N} Q_i$$

6. To obtain the vertical dimension of a ground-based volume source, divide the quantity obtained in 4) by the quantity obtained in 5).

$$\frac{\sum_{i=1}^{N} MWPR_i}{\sum_{i=1}^{N} Q_i}$$

7. If the vertical dimension of the ground-based volume source is calculated to be greater than 10 meters, the value is to be set equal to 10 meters. In no instance is the vertical dimension of a volume source to exceed 10 meters.

The initial vertical dimension (SIGMA-Z0) for a ground=based volume source is then equal to the vertical dimension of the source specified by the user divided by 2.15.

4. Sum the products of mean plume rise and emission rate for each of the sources contained in the volume source.

$$\sum_{i=1}^{N} MWPR_i$$

5. Sum the emission rates for each of the sources contained in the volume source.

$$\sum_{i=1}^{N} Q_i$$

6. To obtain the vertical dimension of a ground-based volume source, divide the quantity obtained in 4) by the quantity obtained in 5).

$$\frac{\sum_{i=1}^{N} MWPR_i}{\sum_{i=1}^{N} Q_i}$$

7. If the vertical dimension of the ground-based volume source is calculated to be greater than 10 meters, the value is to be set equal to 10 meters. In no instance is the vertical dimension of a volume source to exceed 10 meters.

The initial vertical dimension (SIGMA-Z0) for a ground-based volume source is then equal to the vertical dimension of the source specified by the user divided by 2.15.

ii. Operational Fugitive Emissions

The initial vertical dimension (SIGMA-Z0) of the volume source representing operational fugitive emissions is to be equal to the vertical extent of the ROC fugitive emitting sources (not to exceed 10 meters) divided by 2.15.

d. Initial Lateral Dimension (SIGMA-Y0) input as VS

Rather than model construction emissions or other volume sources as one large volume source, the emissions are to be modeled as a larger number of smaller volume sources. The width of a volume source, X_o, is to be less than or equal to 50 meters in all cases. The value of the initial lateral dimension (SIGMA-YO) is to be equal to $x_o/4.3$.

2. Line Sources (ITYPE = 1)

Emissions resulting from construction combustive activities which occur in a relatively narrow corridor (such as pipeline trenching, pipeline ROW preparation and pipe handling) are to be modeled as line sources. Line sources are represented by a series of adjacent volume sources, the number of volume sources (N) being equal to the length/width of the line source.

a. Emission Rate (Q)

Specifics of line source emission rates are equivalent to those for volume sources. The distribution of emissions along the line source is to be determined by the construction activities being simulated.

b. Height of Base of Source Above Surface (HS)

Specifics of the height of the base of the source above the surface for line sources are equivalent to those for volume sources.

c. Initial Vertical Dimension (SIGMA-Z0), input as TS

Specifics of the initial vertical dimensions for line sources are equivalent to those for volume sources.

d. Initial Lateral Dimension (SIGMA-Y0), input as VS

The width (X_o) of adjacent volume sources used to represent a line source is to be less than or equal to 50 meters in all cases. In most circumstances, the

the value of X_o for line sources will be on the order of 2Ø meters of less. The value of the initial lateral dimension (SIGMA-YØ) is to equal X_o/2.15 for adjacent volume sources used to represent a line source.

3. Area Sources (ITYPE=2)

Emissions which are to be modeled as area sources include fugitive emissions of PM-1Ø/TSP and ROC. Area sources are characterized by non-buoyant emissions containing negligible vertical extent of release.

Fugitive particulate (PM-1Ø, TSP) emission sources include areas of disturbed ground, which may be present during both the construction (clearing, grading, excavating) and operational (open pits, unpaved roads, parking lots) phases of a facility's life. Also included are areas of exposed material storage (stockpiles) and segments of material transport where potential fugitive emissions may occur (uncovered haul trucks or rail cars, emissions from unpaved roads). Fugitive emissions may also occur during stages of material handling where particulate material is exposed to the atmosphere (uncovered conveyors, hoppers and crushers).

Fugitive hydrocarbon (ROC) emissions emanating from a specific level are to be modeled as area sources. This may include fugitive emissions from valves, flanges, venting and other connections which occur at ground level or at an elevated level or deck if on a building or structure. Sources of fugitive ROC emissions with a vertical extent greater than one meter are to be modeled as volume sources.

a. Emission Rate (Q)

The emission rate for area sources is to be specified in grams per square meter per second (g/s-m^2). The worst-case one-hour emission rate is to be used for all averaging periods, except for annual average which will utilize an annual average emission rate. All emission rates are to be calculated in a manner consistent with District approved procedures.

With respect to modeling fugitive PM-1Ø emissions, a PM-1Ø/TSP ratio of Ø.64 is to be used in the absence of specific information (ARB, 1987).

b. Height of Source Above Surface (HS)

The height (HS) of the area source above the surface is to be specified as the height from which the emissions emanate. For example, all ground-based activities which result in fugitive emissions are to be modeled with HS equal to 0. In cases of modeling fugitive emissions as area sources which emanate from an elevated level or deck, the value of HS is to equal the height of the level or deck above the ground surface.

c. width of a Square Area Source (X_o, input as VS)

Rather than model area sources as one large area source, the emissions are to be modeled as a larger number of smaller area sources. The width of an area source, X_o, is to be less than or equal to 50 meters in all cases.

D. Scheduling and Averaging Period Considerations

1. Onshore Construction Combustive Emissions

a. Scheduling Methodology

For purposes of modeling air quality impacts from construction combustive emissions, construction activities are to be analyzed consistent with any operating limitation (enforced by permit conditions) which specify the period(s) of the year and/or hours of the day the construction activities are to occur. Should the scheduling of a particular construction scenario be unknown or should permit conditions limiting periods of construction not be in effect, the construction combustive activities are to be modeled as occurring 24 hours a day, 365 days a year. As an alternative, an applicant may agree to operating limitations to construct for specific hours of the day and /or periods of the year.

In order to provide a degree of potential construction scheduling flexibility to an applicant, a one-hour period both preceding and following the projected hours of construction is to be analyzed. Likewise, for proposed construction activities less than three months in duration, a one-month period both preceding and following the projected period of construction is to be analyzed. For proposed construction activities longer than three months in duration, a minimum two-month period both preceding and following the projected period of construction is to be analyzed. However, the entire period to be analyzed is not to exceed one year.*

As an example, construction activities which are projected to occur from 0700 through 1700 local standard time are to be modeled as 0600 through 1800 in the air quality impact analysis. This is equivalent to model input hours 7 through 18, with model input hour 7 equaling the interval from 0600 to 0700. It is important to model all construction activities consistent with local standard time as the meteorological data input into ISCST is based on this time scheme. To continue this example, construction activities which are projected to occur from 1 February through 1 August are to be analyzed using the meteorological data from the period 1 December through 1 October.

b. Modeling Methodology and Averaging Period Considerations

Modeling air quality impacts for all averaging periods from construction combustive emissions occurring during specific hours of the day or periods of the year can be accomplished in the following manner:

i. Utilize the period of pre-construction monitoring (PCM) meteorological data determined per the scheduling method presented in Section D.1.a.

ii. Specify ISW(23)=3 in the input option list.

iii. Specify QFLG=0 in the input option list.

iv. For parameter QTK of the input option list, apply a scalar value of 1.0 for all hours of potential construction activity as determined per the scheduling method presented in Section D.1.a. (example: Hours 7 through 18) and apply a scalar value of 0.0 for all remaining hours.

* The one year period is not necessarily a calendar year, but is the running year during which the maximum construction emissions would occur.

The annual average concentration from construction activities which are conditioned to occur for less than a one-year period is to be calculated by multiplying the average concentration for the number of days of meteorology modeled (calculated by ISCST when ISW(15)=1) by the number of days in the construction period analyzed (as determined by the scheduling method presented in Section D.1.a) and dividing by 365.

In some instances, there may be several distinct construction activities occurring at a single site during a one-year period which are conditioned to not occur simultaneously. In these instances, each construction activity is to be analyzed with the schedule determined per the scheduling methodology presented in Section D.1.a. Should separate construction activity analyses overlap due to consideration of the one-month period preceding and following the conditioned activity, then the analyses are to be performed separately with the period of time beyond the period of conditioned activity being split equally so as to not result in modeled overlap between scenarios. Short-term (less than or equal to 24 hours) averaging periods are to be obtained directly from the modeling results of each construction activity. The annual average is then obtained by summing the scaled "annual average" impact from each separate construction activity. The annual average impact is not necessarily a calendar year, but is the running year during which the maximum construction impacts would occur.

2. Onshore Construction Fugitive Emissions

Fugitive dust emissions occurring as a result of construction activities are to be modeled consistent with the protocol for construction combustive emissions except that the fugitive emissions are to be modeled for all 24 hours of the day. This is consistent with the district protocol of calculating average fugitive dust emissions based on a 24 hour day which includes periods of active construction as well as periods of inactivity. ISW(23) and QFLG are to be both specified as 0 and QTK is not to be specified.

3. Onshore Operational Fugitive Emissions (ROC)

Operational fugitive ROC emissions are assumed to be constant and not a function of time of day. ISW(23) and QFLQ are to be both specified as 0 and QTK is not to be specified. Air quality impacts for all averaging periods are to be modeled using the entire year of pre-construction monitoring (PCM) meteorological data.

4. Onshore Operational Fugitive Emissions (TSP, PM-10)

Those emissions which are independent of the operational schedule of the facility are to be modeled in the same manner as fugitive ROC in 3 above. This may include fugitive dust from stockpiles, excavations, graded areas, etc. Emissions which are dependent upon facility operation, such as those from conveyors, crushers, etc., are to be modeled in the manner of the construction emissions in Section 1.a above, with the assumption that the facility is in operation 365 days a year.

E. Meteorology

Hourly meteorological inputs required by ISCST are wind speed, flow vector (direction toward which the wind is blowing (for both ISW(19)=1 and 2), temperature, stability class, and mixing height. The user should not input the hourly wind profile exponent and vertical potential temperature gradient, but should use the internal default values by specifying both ISW(21) and ISW(22) as 1 in the input option list.

for informational purposes, the default wind profile exponents a a function of stability class are:

.10, .15, .20, .25, .30, .30

and the default vertical potential temperature gradients as a function of stability class are:

0., 0., 0., 0., .02, .035.

Hourly wind speed, wind direction and temperature are to be obtained from previously approved APCD pre-construction monitoring. It is important to note that the direction from which the wind is blowing must be reversed 180 degrees to conform with the average flow vector (the direction toward which the wind is blowing). Stability class is to be obtained in a manner consistent with EPA document" Guideline on Air Quality Models (Revised)," July, 1986 (USEPA, 1986). Twice daily mixing heights are available from Pt. Mugu and Vandenberg. If unavailable, hourly mixing heights can be estimated from (Holzworth, 1972).

1. Calm Scenarios

   a. All wind speeds less than 1 m/sec must be converted to 1 m/sec prior to input to the ISCST model.

   b. The CRSTER pre-processor, which may be utilized, deals with calm winds (hourly mean wind speed approaching 0) in the following manner:

      i. wind speeds less than 1 m/sec are set equal to 1 m/sec.

      ii The wind direction is set equal to the value for the last non-calm hour.

F. Background Air Quality

To assess one, three and eight-hour background air quality values for construction activities which occur for only a portion of the day, use the observed background air quality only for the hours of construction activities which were modeled. Likewise, to model construction activities which occur for only a portion of the year, use the observed background air quality only for the portion of the year during which construction activities were modeled. Twenty-four hour average background air quality values are to be selected from the portion of the year during which the construction activities were modeled. Annual average background air quality values are to be obtained from the year of PCM ambient air quality data collected by the applicant. Otherwise, the protocol included in Sections 6.II.D. and 6.II.E. of the District's Permit Processing Manual are to be used.

G. Receptor Grid Spacing

Receptor points shall be placed as follows:

1. At 250 meter intervals on a cartesian grid.

2. At specific discrete points to ensure that maximum potential impact is modeled (for example, on facility boundary line). The receptor grid should be large enough in extent to cover region(s) of significant impact(s).

3. Receptors shall not be placed inside applicant's facility boundaries. Receptors are to be placed starting at discrete points along the facility boundary line or along an arc 100 meters away from the nearest source(s) (or $X_o/2$ + 100 meters away from the nearest area source(s)) depending on which distance is greater from the source(s) in question.

4. Refer to discussion of ISW(4) for specifics of terrain considerations. If terrain elevations are to be utilized, they are to be obtained from 7.5 minute USGS or more detailed topographic maps.

H. Modifications

In order to assess cumulative air quality impacts from different source types, modeled pollutant concentrations from point sources and non-point sources which impact the same receptor during a given hour are to be summed together. This will require the use of a post-processor program and modification to the ISCST code to output concentrations in a format acceptable to the post-processor program and the required modification to ISCST.

VI. Modeling of Offshore and Associated Coastal Source Emissions

A. General Information

This section outlines the Santa Barbara County Air Pollution Control District (District) protocol for modeling inert pollutant air quality impacts from offshore sources and coastal (i.e., within 1 km) point sources which are directly associated with offshore sources of air emissions. The air quality model presented in this section is OCDCPM, which may be used for sources in these situations.

The OCDCPM model is to be used for all inert pollutants and all averaging periods. OCDCPM is available on magnetic tape from the District.

This protocol is designed to cover the majority of scenarios which are anticipated to be analyzed by the District. However, should a particular scenario include components which are not covered in this protocol, then the District will determine the appropriate procedures to be used in the Air Quality Impact Analysis.

1. Model Description

The OCDCPM model is a hybrid of the Offshore and Coastal Dispersion (OCD) model (Version 3.Ø, as updated in January 1986) developed by the Minerals Management Service (MMS), and the Environmental Protection Agency's (EPA) COMPLEX-I and MPTER models. OCD was developed for use with offshore sources. COMPLEX-I and MPTER are EPA UNAMAP models for multiple sources in complex and simple to rolling terrain, respectively.

The OCDCPM hybrid model was developed by the District with technical guidance from EPA Region IX and the California Air Resources Board. The model uses the OCD algorithm to accomplish dispersion from offshore sources. At the shoreline, the OCD dispersion is continued for receptors at or below the lowest stack height. For receptors located above the lowest stack height, a transition to the COMPLEX-I dispersion and terrain algorithms is accomplished at the shoreline using a virtual point source treatment. In addition, a calculation is performed for above stack receptors using the OCD algorithm. For these complex terrain receptors, the higher of the OCD and OCD/COMPLEX-I calculations is retained and reported as the impact.

For onshore sources, the OCDCPM model reduces to MPTER for receptors located at or below the lowest stack height, and reduces to COMPLEX-I for above stack receptors. The OCDCPM model chooses and utilizes the appropriate EPA recommended model in each case based on source location (onshore or offshore) and receptor elevation with respect to the lowest stack height.

2. Applicable Source Types

The OCDCPM model is applicable to coastal projects which include offshore sources of air emissions. For example, an oil development project that included emissions from one or more offshore platforms, associated mobile sources such as tankers or supply boats, and coastal processing facilities would use the OCDCPM model for all offshore emissions and for all onshore point source emissions. Offshore mobile sources, such as vessels and barges, are to be simulated with OCDCPM as a series of point sources covering the expected area of emissions during each applicable averaging period. Fugitive hydrocarbon emissions from offshore sources are also to be simulated as multiple point sources covering the expected area of emissions.

Onshore non-point (area, line, or volume) sources, such as those produced by construction activities or fugitive emissions, should be modeled with the ISCST model (see Section 6-V of this manual). Onshore projects which do not include offshore emission sources should model point source emissions using either COMPLEX-II or MPTER, depending on the terrain height in the impact area (see Sections 6-II and 6-III of this manual). In addition, fumigation conditions are also to be modeled for both onshore and offshore sources to assess project compliance with the one-hour NO_2 and SO_2 California Ambient Air Quality Standards (CAAQS) (refer to Section 6-IV of this manual).

3. Specifications for District Submittals

All Air Quality Impact Analyses performed for the proposed project utilizing the OCDCPM model shall calculate the maximum impact value as the peak modeled impact value, from the combined onshore and offshore contributions, plus 20 percent of the peak modeled impact value (peak value x 1.2) to adjust for observed under predictions associated with the individual models used in this approach. It is important to note that OCDCPM does not include an algorithm to multiply the peak modeled concentration by 1.2; this must be done by the user as a post-processing exercise.

B. OCDCPM Model Input Requirements

This section discusses principal model input requirements. For additional information, refer to Sections 6-II and 6-III of this manual, and to OCD and MPTER documentation (Hanna, et al., 1984; Pierce and Turner, 1980).

1. Main Model (IOPT) Option Specifications

Table 6-VI-1 lists the major model options to be used in simulations with OCDCPM. The listed specifications should be used for all submittals to the District. Should the applicant wish to employ option specifications other than those listed which do not affect the concentration calculations, they may do so with proper notification of the District prior to submission of modeling results.

IOPT (1) through IOPT (24) have the same specifications as in the COMPLEX-II, and MPTER models.

IOPT (25) should be set to one (1) in all cases, which will enable the model to read the additional overwater meteorological data (refer to Section 6-VI-D.1.b. of this manual for a discussion of the overwater meteorological data set).

IOPT (26) should be set to zero (0) (no pollutant decay rate) and IOPT (27) should also be set to zero (0) (do not adjust reflection factor for sloping terrain). IOPT (27) only affects calculations using the OCD terrain algorithm.

IOPT (28) is the complex terrain option. This parameter is the same as IOPT (25) in the COMPLEX-II model and should be set to one (1) in all cases.

2. Overland Wind and Terrain Options

This section of the model input stream requires information concerning the onshore anemometer height, the surface roughness length, terrain adjustment factors, the minimum height of the plume above terrain, the latitude of the source region, and wind profile exponents.

The actual height at which the wind data used in modeling were taken should be specified as the anemometer height (HANE).

Surface roughness lengths (ZOL) for various types of terrain are listed in Table 6-VI-2. A weighted average roughness length for the source/receptor area should be used based on the distribution of terrain and vegetation types.

The following terrain adjustment factors (CONTER) should be used for stability classes A through F, respectively:

0.5, 0.5, 0.5, 0.5, 0.0, 0.0

The minimum height of the plume above terrain (ZMIN) should be set to 10.0 meters.

TABLE 6-VI-1.
MAIN MODEL OPTIONS FOR OCDCPM SIMULATIONS

OPTION	OPTION LIST	OPTION SPECIFICATION: Ø = IGNORE OPTION 1 = USE OPTION
1	USE TERRAIN ADJUSTMENTS	1
2	DO NOT INCLUDE STACK DOWNWASH CALCULATIONS	Ø
3	DO NOT INCLUDE GRADUAL PLUME RISE CALCULATIONS	Ø
4	USE BUOYANCY INDUCED DISPERSION	1
5	READ MET DATA FROM CARDS	Ø or 1
6	READ HOURLY EMISSIONS	Ø
7	SPECIFY SIGNIFICANT SOURCES	Ø
8	READ RADIAL DISTANCES TO GENERATE RECEPTORS	Ø
	PRINTED OUTPUT OPTIONS	
9	DELETE EMISSIONS WITH HEIGHT TABLE	1
1Ø	DELETE MET DATA SUMMARY FOR AVG PERIOD	1
11	DELETE HOURLY CONTRIBUTIONS	1
12	DELETE MET DATA ON HOURLY CONTRIBUTIONS	1
13	DELETE CASE STUDY PRINTOUT OF PLUME TRANSPORT AND DISPERSION ON HOURLY CONTRIBUTIONS	1
14	DELETE HOURLY SUMMARY	1
15	DELETE MET DATA ON HRLY SUMMARY	1
16	DELETE CASE STUDY PRINTOUT OF PLUME TRANSPORT AND DISPERSION ON HOURLY SUMMARY	1
17	DELETE AVG-PERIOD CONTRIBUTIONS	1
18	DELETE AVERAGING PERIOD SUMMARY	1
19	DELETE AVG CONCENTRATIONS AND HI-5 TABLES	Ø
	OTHER CONTROL AND OUTPUT OPTIONS	
2Ø	RUN IS PART OF A SEGMENTED RUN (Disabled)	Ø
21	WRITE PARTIAL CONC TO DISK OR TAPE (Disabled)	Ø
22	WRITE HOURLY CONC TO DISK OR TAPE	Ø
23	WRITE AVG-PERIOD CONC TO DISK OR TAPE (Disabled)	Ø
24	PUNCH AVG-PERIOD CONC ONTO CARDS (Disabled)	Ø
25	READ OVERWATER METEOROLOGICAL DATA	1
26	SPECIFY POLLUTANT DECAY RATE	Ø
27	ADJUST REFLECTION FACTOR FOR SLOPING TERRAIN	Ø
28	COMPLEX TERRAIN OPTION	1

TABLE 6-VI-2.

TYPICAL SURFACE ROUGHNESS LENGTHS FOR VARIOUS GROUND COVERS[a]

GROUND COVER	SURFACE ROUGHNESS LENGTHS (meters)
Water surface[b]	Ø.ØØØØ1 - Ø.ØØ4
Fallow field or low grass	Ø.Ø1 - Ø.Ø3
High grass	Ø.Ø3 - Ø.1Ø
Sand dunes	Ø.Ø5 - Ø.1Ø
Flat rural, few trees[c]	Ø.ØØ3 - Ø.Ø3
Rural, rolling terrain, few trees[c]	Ø.Ø1 - Ø.15
Woods[c]	1.ØØ
Suburban[c]	Ø.5 - 1.5
Urban[c]	1.5 - 4.Ø
Dense vegetation cover	1/8 of the average canopy height

[a]From Hanna, et al., 1984.

[b]Roughness length increases with increasing wind speed.

[c]Roughness length increases for taller or more closely spaced obstacles to wind flow, or for higher terrain obstacles.

The following wind profile exponents (PL) should be used:

0.10, 0.15, 0.20, 0.25, 0.30, 0.30

C. Point Source Description Information

The following inputs are required for each source of emissions modeled: source location (Universal Transverse Mercator (UTM) coordinates), pollutant emission rate, height of tallest building at or near stack location, height of stack top above reference level, stack gas temperature, stack inside diameter, stack gas exit velocity, deviation of stack angle from the vertical, and the source "ground level" elevation. All of these parameters must be reviewed by the District engineering staff prior to submission of modeling results.

Maximum hourly emission rates are to be used in modeling all averaging periods less than or equal to 24 hours. Annual average emission rates are to be used in modeling all annual average concentrations. Emission rates are described more fully in Section 6.II.C. of this manual.

The height of the building or obstacle at or near the stack location that exerts primary influence on building downwash effects must be specified. In many cases, this will be the building to which the stack is attached. However, if a nearby building or other solid structure has larger dimensions than the building to which the stack is attached, the Good Engineering Practice (GEP) stack height should be calculated for each building (refer to Rule 205.C.1.a.16 for GEP stack height definition), and the height of the building with the higher GEP stack height should be used for this parameter. For an offshore platform, this parameter will be the height of the tallest solid structure or section on the top deck of the platform, specified as the height above the source "ground level." The source "ground level" is defined below.

The stack height is specified as the height above the source "ground level." For onshore sources, the source "ground level" is the local ground elevation. For simple offshore sources in contact with the water (crew and supply boats, tankers, construction barges, etc.), the water level is the source "ground level" (ELP(NPT)=0.). For more complex offshore sources that extend above the water on stilts or legs, such as drilling or production platforms, the source "ground level" is the base structure above which the stack extends. For instance, the source "ground level" for a multideck platform would be the height above the water level of the lowest deck. The definition of stack height for a non-vertical stack is discussed below.

The deviation of the stack angle from the vertical is specified in degrees. A vertical stack would have a stack angle deviation of 0.0, a horizontal stack would show a deviation of 90.0. Other angles are possible. For a non-vertical stack, the stack height is not defined as the physical length of the stack, but rather is the height of the center of the stack top above the source "ground level."

The final parameter required in this section is the elevation of the source "ground level" defined above. For onshore sources, this is the ground elevation above mean sea level. For platforms, this is the elevation above mean sea level of the lowest platform deck. The elevation of the source "ground level" is to be specified in feet or meters with the appropriate multiplier indicated for variable CELM in card type 4. For simple offshore sources in contact with the water (i.e. crew and supply boats, tankers, construction barges, etc.) the source "ground level" elevation (ELP(NPT)) will be zero (0.).

As an example of the interrelationship of the parameters described above, consider an offshore platform with three decks, at 15, 25, and 35 meters above the water surface. The source "ground level" would be the elevation of the lowest deck, 15 meters. All stack heights would be defined as heights above the lowest deck. For instance, a diesel source with a vertical stack that was two (2) meters tall and was located on the second deck would have a value of (25 - 15) + 2 = 12 meters for the stack height. A flare boom with a length of 20 meters that extended from the top deck at a 45 degree angle would have a stack height of (35 - 15) + (sin 45 degrees x 20) = 34.14 meters. The height of the obstacle influencing downwash would be the height of the largest solid structure extending above the upper deck. For example, a three (3) meter high enclosure on the upper deck would be specified as a height above the source "ground level" of 15 meters, that is (35 - 15) + 3 = 23 meters.

D. Meteorology

As the OCDCPM model is to be applied to offshore sources and coastal point sources associated with offshore facilities, both overland and overwater meteorology are required inputs. In order for OCDCPM to consider overland and overwater meteorological data inputs, both IOPT(5) and IOPT(25) must be set equal to 1.

Default meteorological data, which can be generated internally by OCDCPM when measured data are not available, are not to be used. All meteorological inputs to OCDCPM must be obtained externally either as data actually measured and accepted by the District, or as specified values listed in Section D.1.c. For every hour contained in the simultaneous overland and overwater data sets, all parameters must be specified with a value. This will result in OCDCPM not calculating default meteorological data or applying the climatological values of data provided by the user.

Overland and overwater preconstruction monitoring data sets to be used as input to OCDCPM, must be of at least one year duration with a minimum 90 percent approved data capture rate. The following procedure may be used to "fill in" the data set to 100% capture. Generally, short periods of one to six hours may be interpolated, with District approval, from data at the same site. Longer periods of missing data may be filled in with actual data from another site(s) which the District has approved as representative. Data from offshore sites can not be used to substitute for missing data from onshore sites, although with District approval, data from onshore sites may be substituted for data from an offshore site if no other representative offshore site is available.

In all cases, overwater turbulent intensities (IYW, IZW) will be the reasonable worst case values presented in Table 6-IV-4.

It must be emphasized that the requirement to utilize all or part of the reasonable worst-case meteorological data as prescribed above does not imply that the applicant is not required to collect preconstruction monitoring data. Applicants will be required to collect and have validated by the District at least one year of air quality and meteorological data prior to the District considering the project application as complete. The reasonable worst-case meteorological data, are to be used in lieu of actual data when the actual data are missing for extended periods, when the data have not been collected according to the Districts monitoring protocol, or if the data are deemed unacceptable by the District. Analyses outside the District permitting process which may not require preconstruction monitoring of meteorological data must utilize the reasonable worst-case values.

1. Meteorological Data Set Considerations

This section presents the meteorological data sets which can be utilized by OCDCPM. Meteorological input parameters required by OCDCPM to satisfy District requirements are discussed with respect to the hierarchy and manner in which these data are to be input to the model.

a. Overland Meteorology

Overland meteorological parameters required by OCDCPM are wind speed, wind direction, temperature, stability class, and mixing height. At a minimum, hourly averaged wind speed, wind direction, stability class and temperature are to be obtained from the District-approved preconstruction monitoring program for the proposed project (SBAPCD, 1985). A discussion of the overland meteorological parameters and the hierarchy of their use is as follows:

i. Overland wind direction

- use measured overland values, if available.
- If measured overland values are not available, the applicant must use reasonable worst-case meteorology (Section D.1.c.) for all parameters of both the overland and additional meteorological data sets.

ii. Overland wind speed

- use measured overland values, if available.

Calm periods in the overland data set are to be handled as follows:

- All wind speeds less than 1 m/sec must be converted to 1 m/sec prior to input to the OCDCPM model.

- The CRSTER pre-processor, which may be utilized, deals with calm winds (hourly mean wind speed approaching 0) in the following manner:

  - Wind speeds less than 1 m/sec are set equal to 1 m/sec.

  - The wind direction is set equal to the value for the last non-calm hour.

- If measured overland values are not available, the applicant must use reasonable worst-case meteorology (Section D.1.c.) for all parameters of both the overland and additional meteorological data sets.

iii. Overland air temperature

- Use measured overland values, if available.

- If measured values are not available, use the value specified in Section D.1.c. for all hours.

iv. Overland stability class

- Use values calculated per District procedures (SBAPCD, 1983; USEPA, 1986) if the data used to calculate stability class are available.

- If calculated values are not available, the applicant must use reasonable worst-case meteorology (Section D.1.c.) for all parameters of both the overland and additional meteorological data sets.

v. Overland mixing height

Twice daily mixing heights are available from Pt. Mugu and Vandenberg. If unavailable, hourly mixing heights can be estimated from Holzworth (1972).

iii. Overwater mixing height

- Use measured overwater values, if available, and specify JOPT(3)=1.

- If overwater values are not available and an actual onshore data set is being utilized, use a value of 250 meters.

- If reasonable worst-case meteorological data are to be used, use the range of values specified in Section D.1.c. and specify JOPT(3)=1.

iv. Overwater relative humidity

- Use measured overwater values, if available, and specify:

  JOPT(4)=1 if relative humidity is provided;
  JOPT(4)=2 if wet bulb temperature is provided;
  JOPT(4)=3 if dew point temperature is provided.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(4)=1.

v. Overwater air temperature

- Use measured overwater values, if available, and specify JOPT(5)=1.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(5)=1.

vi. Water surface temperature

- Use measured overwater values, if available, and specify:

  JOPT(6)=1 if water surface is provided;
  JOPT(6)=2 if air minus water surface temperature is provided.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(6)=2.

ii. Overwater wind speed

- Use measured overwater values if available and specify JOPT(2)=1.

- If overwater values are not available, incorporate overland values from District-approved onshore site directly into the additional meteorological data set and specify JOPT(2)=1. This will result in not allowing OCDCPM to calculate a default offshore wind speed for the overland data.

- If overwater and overland values are not available, use value specified in Section D.1.c. for all hours and specify JOPT(2)=1. If both overwater and overland wind directions are not available, the applicant must use reasonable worst-case meteorology (Section D.1.c.) for all parameters of both the additional meteorological data and overland data sets.

iii. Overwater mixing height

- Use measured overwater values, if available, and specify JOPT(3)=1.

- If overwater values are not available and an actual onshore data set is being utilized, use a value of 250 meters.

- If reasonable worst-case meteorological data are to be used, use the range of values specified in Section D.1.c. and specify JOPT(3)=1.

iv. Overwater relative humidity

- Use measured overwater values, if available, and specify:

  JOPT(4)=1 if relative humidity is provided;
  JOPT(4)=2 if wet bulb temperature is provided;
  JOPT(4)=3 if dew point temperature is provided.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(4)=1.

v. Overwater air temperature

- Use measured overwater values, if available, and specify JOPT(5)=1.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(5)=1.

vi. Water surface temperature

- Use measured overwater values, if available, and specify:

  JOPT(6)=1 if water surface is provided;
  JOPT(6)=2 if air minus water surface temperature is provided.

- If overwater values are not available, use the value specified in Section D.1.c. for all hours and specify JOPT(6)=2.

vii. Overwater wind direction shear

- In all instances, a value of -999.9 (indicating missing data) is to be used for all hours. JOPT(7) is to be specified as 0.

viii. Overwater horizontal turbulence intensity

- A value of 0.045 is to be used for all hours, in all instances. Actual measurements of this parameter will not be approved for use by the District until further studies have been conducted to examine the OCDCPM model parameterization of plume dimensions from turbulence intensities. JOPT(8) is to be specified as 1 in all situations. This will result in not allowing OCDCPM to calculate default values of overwater horizontal turbulence intensities.

ix. Overwater vertical turbulence intensity

- A value of 0.020 is to be used for all hours, in all instances. Actual measurements of this parameter will not be approved for use by the District until further studies have been conducted to examine the OCDCPM model parameterization of plume dimensions from turbulence intensities. JOPT(9) is to be specified as 1 in all situations. This will result in not allowing OCDCPM to calculate default values of overwater vertical turbulence intensities.

x. Overland turbulence intensities

- Overland horizontal and vertical turbulence intensities (IYL and IZL, respectively) are not to be used as direct input to OCDCPM. Utilize a value of -999.9 for this parameter which indicates that overland turbulence intensities will not be used. Specify JOPT(10) as 0 in all situations. Overland horizontal/vertical turbulence intensities can be used to calculate stability classifications per District procedures and used as input in the overland data set.

xi. Overwater vertical potential temperature gradient

- In all instances, the value specified in Section D.1.c. is to be used for all hours. JOPT(11) is to be specified as 1.

Table 6-VI-3 summarizes the additional meteorological data options which can be used in the OCDCPM simulations.

The height of the overwater anemometer and air temperature sensor must also be provided. Specify the actual height of these instruments in meters above the water level or utilize a value of 10 meters if these parameters are not measured (reasonable worst-case meteorology is being utilized).

c. Reasonable Worst-Case Meteorological Data

The adequacy of any overwater or overland meteorological data set will be determined by District staff on a case-by-case basis. The applicant should review proposed meteorological data with the District prior to commencement of OCDCPM modeling. If certain data requirements listed in Sections VI.D.1.a. and VI.D.1.b. are not met, the analysis must utilize reasonable worst-case meteorology as input to OCDCPM. The reasonable worst-case data set is presented in Table 6-VI-4.

If the use of reasonable worst case meteorology is required, then the user is to prepare an hourly data set as specified in Table 6-VI-4 of this manual, including all wind directions likely to produce maximum impacts from the proposed project on coastal terrain. A variety of mixing heights should be examined in initial model runs to determine the height that will result in the highest modeled impacts. Equivalent overland and overwater mixing heights from 100 to 300 meters, in 50 meter increments, should be assessed for each wind direction modeled. The District has created an interactive FORTRAN program that will assemble an appropriate data set when reasonable worst-case meteorological data are required for all parameters. Potential users may contact the District for a copy of the program.

TABLE 6-VI-3.
ADDITIONAL METEOROLOGICAL DATA OPTIONS FOR OCDCPM SIMULATIONS

OPTION	OPTION LIST	OPTION SPECIFICATION*
1	OVERWATER WIND DIRECTION PROVIDED	0 or 1
2	OVERWATER WIND SPEED PROVIDED	1
3	OVERWATER MIXING HEIGHT PROVIDED	1
4	OVERWATER HUMIDITY SPECIFICATION	1,2 or 3
5	OVERWATER AIR TEMPERATURE PROVIDED	1
6	WATER SURFACE TEMPERATURE SPECIFICATION	1 or 2
7	OVERWATER WIND DIRECTION SHEAR PROVIDED	0
8	OVERWATER HORIZONTAL TURBULENCE INTENSITY PROVIDED	1
9	OVERWATER VERTICAL TURBULENCE INTENSITY PROVIDED	1
10	OVERLAND TURBULENCE INTENSITY PROVIDED	0
11	OVERWATER POTENTIAL TEMPERATURE GRADIENT PROVIDED	1

* Unless otherwise specified, 1 = provided, 0 = not provided, or do not use.

TABLE 6-IV-4. REASONABLE WORST-CASE METEOROLOGICAL DATA SET FOR OCDCPM SIMULATIONS

PARAMETER	INPUT VALUES (S)
<u>Overwater</u>	
Wind Direction (WD)	Applicable sector of wind directions in one degree (1^o) increments
Wind Speed (WS)	1.0 m/sec
Mixing Height (HLW)	Height to result in highest modeled impacts or 100 to 300 m in 50 m increments
Relative Humidity (WHUM)	90 percent
Air Temperature (WTA)	290^o K
Air to Sea Surface (WTS) Temperature Difference	$+2.0^o$ K
Wind Direction Shear (WDSHR)	-999.9
Overwater Horizontal (IYW) Turbulence Intensity	0.045
Overwater Vertical (IZW) Turbulence Intensity	0.020
Overland Horizontal (IYL) Turbulence Intensity	-999.9
Overland Vertical (IZL) Turbulence Intensity	-999.9
Vertical Temperature Gradient (WDTHDZ)	0.05^ok/m
<u>Overland</u>	
Wind Direction (WD)	Same directions as used for overwater data set
Wind Speed (WS)	1.0 m/sec
Mixing Height (HLH)	Same mixing heights as used for overwater data set
Stability Class (KST)	6 (Stability Class F)
Air Temperature (TEMP)	290^o K

When utilizing reasonable worst-case meteorological data, maximum modeled concentrations will be representative of one-hour averaging periods only. Table 6-VI-5 lists multiplying factors which are to be used to convert the maximum one-hour modeled concentrations to concentrations representative of longer averaging periods.

TABLE 6-VI-5.
FACTORS TO CONVERT ONE-HOUR MODELED CONCENTRATIONS TO LONGER AVERAGING PERIODS.

Modeling Result Averaging Period	Averaging Period	Multiplying Factor
1-hr	3-hr	0.90
1-hr	8-hr	0.70
1-hr	24-hr	0.40
1-hr	Annual	0.10

d. Overwater Climatological Values

Card type 14 of the OCDCPM input file requires monthly average values of overwater mixing height, overwater relative humidity, overwater air temperature and overwater air minus water temperature. However, in all cases, hourly values of these parameters will be specified for use in the model, either with actual overwater measurements or with the reasonable worst-case values listed in Section D.1.c. Therefore, the climatological values input to the model will not be utilized. As the user must provide the climatological data in order to keep the input records OCDCPM is reading in proper order, the following values are suggested for input:

i. Climatological values of overwater mixing height by month: 12*250.

ii. Climatological values of overwater relative humidity by month: 12*90.

iii. Climatological values of overwater air temperature by month: 12*290.

iv. Climatological values of overwater air minus water temperatures by month: 12*2.0.

E. Receptor Grid Spacing

Receptor points shall be placed as follows:

a. At 250 meter intervals on a cartesian grid. Receptors for offshore source simulations should begin at the shoreline and continue as far inland as necessary to cover the area(s) of maximum impact.

b. At specific discrete points to ensure that maximum potential impact is modeled (for example, on facility boundary line or on sub-grid size terrain features). The receptor grid should be large enough in extent to cover region(s) of significant impact(s).

c. Receptors shall not be placed inside the applicant's facility boundaries. Receptors are to be placed starting at discrete points along the facility boundary line or along an arc 100 meters away from the nearest source(s), depending on which distance is greater from the source in question.

d. Receptor elevations are to be obtained from 7.5 minute USGS or more detailed topographic maps.

OCDCPM also allows two additional parameters to be entered for each receptor location; the local slope and the slope base elevation. These values should be omitted or entered as zero (0), which will cause the model to compute the terrain slopes from elevation data and shoreline geometry for use in the OCD computation. These parameters are not used in the COMPLEX I/MPTER algorithms and will not be utilized if entered.

Since wind directions are set by the user in the reasonable worst-case data set, the user should take care to ensure that receptors are placed at all locations likely to produce maximum impacts due to project emissions sources. If the emissions are all produced from a single source, or a tight cluster of sources, receptors should be placed at 100 meter intervals on 1 degree radials centered on the source or source cluster. If sources are more widely spaced, a cartesian grid of receptors will be necessary to calculate maximum impacts. This cartesian grid should comply with the requirements outlined in Section 6.VI.B.4. of this manual. In no case shall the cartesian grid receptors be more widely spaced than every 250 meters. At District discretion, a smaller receptor spacing may be required to ensure that maximum impacts are calculated. All receptor sets must be approved by District staff prior to initiation of modeling.

F. Shoreline Geometry

OCDCPM requires specification of the location of the shoreline relative to source and receptor locations. All receptors and sources involved in a given simulation must be within the area specified by the shoreline geometry grid. This may require the user to break simulations down into several shorter runs for particular subsets of sources or receptors since the number of map grid cells that can be specified for a single OCDCPM simulation is limited.

The maximum grid cell length (horizontal or vertical) that should be specified is one-half kilometer. Horizontal and vertical grid cell lengths do not need to be the same as long as each is less than or equal to one-half kilometer. It may be necessary to adjust the designation (as water or land) of individual grid cells to ensure that shoreline receptors are located in a cell specified as "land".

The minimum along wind width for a land or water body to be considered significant should be set equal to the smaller of the horizontal and vertical grid cell lengths.

G. Background Air Quality

Background air quality concentrations should be determined in accordance with the procedures and specifications outlined in Section 6.II.D. and 6.II.E. of this manual.

H. Modifications

In order to assess cumulative air quality impacts from different source types, modeled pollutant concentrations from point sources and non-point sources which impact the same receptor during a given hour are to be summed together. This will require the use of a post-processor program and may require modifications to model code to output concentrations in a format acceptable to the post-processor. The District can provide a FORTRAN post-processor program that will perform this function, along with versions of OCDCPM and ISCST that will work with the post-processor. Please contact District staff for further information.

VII. References

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